Food Insufficiency and American School-Aged Children's Cognitive, Academic, and Psychosocial Development

Katherine Alaimo, PhD*; Christine M. Olson, PhD, RD‡; and Edward A. Frongillo, Jr, PhD‡

ABSTRACT. *Objective.* **This study investigates associations between food insufficiency and cognitive, academic, and psychosocial outcomes for US children and teenagers ages 6 to 11 and 12 to 16 years.**

Methods. **Data from the Third National Health and Nutrition Examination Survey (NHANES III) were analyzed. Children were classified as food-insufficient if the family respondent reported that his or her family sometimes or often did not get enough food to eat. Regression analyses were conducted to test for associations between food insufficiency and cognitive, academic, and psychosocial measures in general and then within lower-risk and higher-risk groups. Regression coefficients and odds ratios for food insufficiency are reported, adjusted for poverty status and other potential confounding factors.**

Results. **After adjusting for confounding variables, 6- to 11-year-old food-insufficient children had significantly lower arithmetic scores and were more likely to have repeated a grade, have seen a psychologist, and have had difficulty getting along with other children. Food-insufficient teenagers were more likely to have seen a psychologist, have been suspended from school, and have had difficulty getting along with other children. Further analyses divided children into lower-risk and higher-risk groups. The associations between food insufficiency and children's outcomes varied by level of risk.**

Conclusions. **The results demonstrate that negative academic and psychosocial outcomes are associated with family-level food insufficiency and provide support for public health efforts to increase the food security of American families.** *Pediatrics* **2001;108:44–53;** ***hunger, food insecurity, food insufficiency, poverty, psychosocial development, cognition, children, NHANES III.***

ABBREVIATIONS. NHANES III, Third National Health and Nutrition Examination Survey; WISC-R, Wechsler Intelligence Scale for Children–Revised; WRAT-R, Wide Range Achievement Test–Revised; PIR, poverty index ratio.

Although they live in a wealthy nation, children in the United States are not immune to poverty and hunger. Almost 1 in 5 American children are poor, and >14 million children under age 18 live in food-insecure households, in which there is a limited or uncertain availability of nutritionally adequate or safe foods.[1,2] Although these numbers demonstrate the magnitude of this social problem, they do not adequately express the real burden of food deprivation for American children.

Research on child development in nonindustrialized countries shows that malnutrition is associated with delays in motor skills, cognitive deficits, and decreases in school performance.[3–6] Current theory postulates that malnutrition's effect occurs through motivational and emotional behaviors rather than influencing intelligence directly. Severely malnourished children have been shown to be apathetic, withdrawn, and passive and have decreased motivation and heightened anxiety.[3,4]

Questions remain about whether the level of food deprivation in the United States is severe enough to affect children's cognitive and psychosocial outcomes. Furthermore, most studies on this topic have been conducted with children younger than school age. Recently, in 2 studies that used data from the Community Childhood Hunger Identification Project surveys, investigators found that school-aged children identified as hungry or at risk of hunger were more likely to have impaired psychosocial function and to have received psychological counseling, were more likely to be absent from or late to school, were more likely to be receiving special education services, and were marginally more likely to have repeated a grade.[7,8]

In this article, we examine the relationships between family food insufficiency and cognitive, academic, and psychosocial outcomes in a nationally representative sample of American school-aged children.

METHODS

NHANES III Data

Data for children ages 6 to 11 years (n = 3286) and 12 to 16 years (n = 2063) were analyzed from the Third National Health and Nutrition Examination Survey (NHANES III), a cross-sectional representative sample of the US civilian noninstitutionalized population living in households (homeless people were not included). The survey was conducted from 1988 to 1994. Mexican Americans and black Americans were oversampled to provide more reliable estimates for these groups. Detailed descriptions of the sample design and operation of the survey have been published elsewhere.[9]

NHANES III included medical and cognitive examinations and interviews conducted with survey participants and proxy respondents. For this analysis, we used data from the Household Family and Household Youth Questionnaires (proxy interviews) conducted in the home, Youth and Proxy Questionnaires conducted

From the *School of Public Health, University of Michigan, Ann Arbor, Michigan; and the ‡Division of Nutritional Sciences, Cornell University, Ithaca, New York.

At the time of the research, Dr Alaimo was at the Division of Nutritional Sciences, Cornell University.

Received for publication Jul 11, 2000; accepted Nov 1, 2000.

Reprint requests to (K.A.) University of Michigan School of Public Health, 109 Observatory, Room M3517, Ann Arbor, MI 48109. E-mail: kalaimo@umich.edu

in the mobile examination centers, and blood samples collected in the mobile examination centers. Of the proxy respondents, 89% were mothers and 6% were fathers of the child; the rest were other relatives or caregivers familiar with the child. All interviews were administered using standard protocols by trained interviewers.[9]

Theoretical Model

Using past research, a theoretical model of the ecological factors affecting school-aged children's cognitive, academic, and psychosocial development was created using variables available from NHANES III.[10–21] We postulated that poor cognitive, academic, and psychosocial outcomes are caused by deficiencies in family and child resources, environmental risks, past nutrition, health, and social risks, and family food insufficiency. The variables used to test this model and their age group availability in NHANES III are shown in Table 1.

Food insufficiency has been previously shown to be negatively associated with children's health status after adjusting for these other factors.[22] In addition to postulating that food insufficiency is associated with poor cognitive, academic, and psychosocial outcomes, we hypothesized that food insufficiency affects children's outcomes through their health status.

Cognitive, Academic, and Psychosocial Outcomes

Cognitive functioning was assessed using 2 subtests of the Wechsler Intelligence Scale for Children–Revised (WISC–R): Block Design, a perceptual organization examination in which children are asked to construct designs out of blocks to match a model; and Digit Span, a freedom-from-distractibility examination in which children are asked to repeat up to 8 digits in forward and reverse directions.[23,24] Academic scores were assessed using 2 subtests of the Wide Range Achievement Test–Revised (WRAT–R): Reading and Arithmetic.[25] The scores for all 4 subtests were standardized to a common scale of 0 to 20 for each age based on samples obtained by the test developers.[10,23,25] The full WISC–R and WRAT–R have been used extensively to assess children's IQ and academic skills. Because only portions of these tests were administered during NHANES III, the subtests cannot be used to calculate an IQ score or an achievement score.

Psychosocial outcomes included the number of days the child had been absent from school in the previous year, whether the child had ever seen a psychiatrist, psychologist, or psychoanalyst for any emotional, mental, or behavioral problems, whether the child had ever been suspended from school, the number of good friends the child had, whether the child had difficulty getting along with other children or teenagers, and whether the child was somewhat shy and slow to make a new friend.

TABLE 1. NHANES III Analyses Variables and Age Groups

NHANES III Variable	Age Group (Years)
Demographics	
Sex	6–11, 12–16
Age	6–11, 12–16
Metropolitan region	6–11, 12–16
Family and child resources	
Poverty status	6–11, 12–16
Race–ethnicity	6–11, 12–16
Family head education	6–11, 12–16
Family head employed	6–11, 12–16
Family head marital status	6–11, 12–16
Number of family moves	6–11, 12–16
Health insurance	6–11, 12–16
Regular source of health care	6–11, 12–16
Food insufficiency	
Family food insufficiency	6–11, 12–16
Environmental risk	
Lead exposure	6–11, 12–16
Crowding	6–11, 12–16
Past nutrition, health and social risk	
Mother's age at child's birth	6–11
Low birth weight	6–11
Prenatal smoke exposure	6–11
Birth complications	6–11
Ever attended child care	6–11, 12–16
Height	6–11, 12–16
Health status	
Proxy-reported health status	6–11, 12–16

Sociodemographic Data and Family and Child Resources

For each child in the survey, information about sex, age, race–ethnicity, health insurance status, family size, number of rooms in the family residence, number of times the family had moved, metropolitan or nonmetropolitan region of residence, family income, whether they had a regular source of health care, and employment status and education of the family head were provided by a responsible adult living in the home. The family head was a person who owned or rented the home where the child lived.

Total family income for the previous 12 months was reported for categories ranging from <$1000 to $80 000 and over, in $1000 increments below $19 999, in $5000 increments between $20 000 and $49 999, and in $10 000 increments between $50 000 and $79 999. A poverty index ratio (PIR) was then calculated by comparing the midpoint of the category and the child's family size with the federal poverty line.[26] These analyses used 3 poverty status categories: low income (PIR $\leq$ 130% of the poverty line, which is the federal cutoff point for eligibility for the Food Stamp Program), middle income (>130% to 350% of the poverty line), and high income (>350% of the poverty line). A child was defined as insured if she or he was covered during the last month by private health insurance, military health care insurance, or Medicaid and if the coverage paid for more than accidents.

Twelve percent of the WISC and WRAT subtests were conducted in Spanish; therefore, for these analyses we controlled for the language in which the test was conducted. For analyses of WRAT and WISC scores, information on race, ethnicity, and the language used during the proxy interview was used to classify children into 4 race–ethnic categories: all non-Hispanic white children and other children with cognitive tests conducted in English, all non-Hispanic black children, Mexican-American children with cognitive tests conducted in English, and Mexican-American or other children with cognitive tests conducted in Spanish. For analyses of other outcomes, we controlled for language by creating the same categories with the main language the child spoke at home.

Food Insufficiency

For the purpose of the NHANES III survey, food insufficiency was defined as "an inadequate amount of food intake due to a lack of money or resources." A child was classified as food-insufficient if the respondent to the family questionnaire reported that the family either sometimes or often did not get enough food to eat. This question has undergone cognitive testing[19,27–31] and has been demonstrated to be associated with food expenditure and nutrient intake.[32–34]

Environmental Risk

For all children, the child's blood lead concentration was measured (in micrograms per deciliter). Family size was divided by the number of rooms in the family residence to determine a continuous measure of crowded housing status.

Past Health, Nutrition, and Social Risk

For children 6 to 11 years, information was collected on the mother's age at birth, the presence of birth complications, low birth weight (birth weight below 2500 g), and any prenatal smoke exposure. A child was classified as having attended childcare if he or she had ever attended childcare where there were 6 or more children before he or she was 4 years old. We used height (in meters) measured at the time of the examination as an indicator of past nutrition status.

Health Status

Proxy-reported health status provides a general summary of children's health. Proxy respondents for the household youth questionnaire were asked to describe the child's health as excellent, very good, good, fair, or poor. For this analysis, the fair and

poor categories were combined because <1% of children were reported to be in poor health.

Statistical Methods

Data for children 6 to 11 years of age and teenagers 12 to 16 years of age were analyzed separately. Using the theoretical model as a guide, the analyses were conducted in 4 stages. First, main effect linear regression models (for continuous outcomes) or logistic (for dichotomous outcomes) or ordinal logistic (for ordinal outcomes) regression models were created to test the hypothesis that food insufficiency is associated with cognitive, academic, or psychosocial outcomes, independent of other potential confounders. All variables in the theoretical model were included in the regression models and included the variables shown in Table 1. Food insufficiency has been shown to be associated with health status.[22] In the second stage of the analyses, health status was added to the models to determine whether the effect of food insufficiency on the outcomes could have acted through health status.

The third stage of the analyses created a risk factor index. Previous research has shown that risk factors affect children's cognitive, academic, and psychosocial performance in an additive fashion.[20,35–39] We used this premise to test for interactions between food insufficiency and other risk factors. We created a risk factor index by summing up the negative risk variables following the approach of Sameroff et al.[35–37] Variables chosen for the risk indices for each age category were based on their availability in the NHANES III survey. For 6- to 11-year-old children, the following were given a value of 1 each and then summed together: an unemployed family head, an unmarried family head, a crowded dwelling (>1 person per room), moved 3 or more times in his or her lifetime, no health insurance, no regular source of health care, blood lead exposure ($\geq$10 μg/dL), birth weight below 2500 g, exposure to prenatal smoke, birth complications, a mother under age 18 at child's birth, and no child care attendance. For teenagers, the following were given a value of 1 each and then summed together: an unemployed family head, an unmarried family head, a crowded dwelling (>1 person per room), moved 3 or more times, no health insurance, no regular source of health care, blood lead exposure, and no child care attendance.

The fourth stage of the analyses looked for interactive associations. The risk indices allowed the children to be divided into 2 categories: lower risk (0–2 risks) and higher risk (3 or more risks). Regression models were created to assess the relationship between food insufficiency and the outcomes within each risk category. In these models, PIR, education of the family head, height, and WISC scores (for academic outcomes) were entered as continuous control variables and sex, age, metropolitan region, and race–ethnicity as categorical control variables. Interactions between food insufficiency and PIR, race–ethnicity, and education of the family head were also assessed and found not to be meaningfully significant.

Sample weights were created for the NHANES III data to account for the oversampling of certain groups, such as black Americans and Mexican Americans, as well as nonresponse. For all analyses, NHANES III weighted data were analyzed using the *svy* commands available in Stata Statistical Software.[40] These commands use the weights and survey cluster design to calculate accurate point estimates and variances. Investigation of outliers and influential data points revealed that unusual children with high sample weights had strong influence on the analyses, which reduced the accuracy of our estimates. To address this problem, we transformed the sample weights using the square root to reduce somewhat the skew of the sample weights.[41] This kept the integrity of the relationship among sampled children to the total population while reducing the influence of a few individual children.

For prevalence estimates and means, missing data were excluded from the analyses. For the regression analyses, all missing data except food insufficiency status were imputed using the *impute* command in STATA, which uses regression equations to fill in missing values based on other nonmissing data in the child's record. Variables included in these regression equations were chosen separately for each imputed variable using backward stepwise regression to screen for associated variables. For dichotomous variables, *impute* was used to predict a probability, and a random value was selected based on this probability. The number of missing values imputed ranged from 0 children missing data for whether the child had a regular source of health care to 255 6- to 11-year-old children and 176 teenagers missing data for their family's poverty index ratio. A total of 336 6- to 11-year-old children and 450 teenagers had at least 1 missing value.

RESULTS

Unadjusted Means and Prevalence Estimates

Unadjusted mean scores and percentages for cognitive, academic, and psychosocial outcomes are shown for food-insufficient and food-sufficient children in Table 2. Mean scores of the WISC and WRAT subtests by demographic characteristics have previously been published.[10] For both younger children and teenagers, WRAT and WISC scores were approximately 1.3 to 2.5 points lower (out of a scale of 20) for food-insufficient children than for food-sufficient children. In addition, food-insufficient children and teenagers were more than twice as likely to have repeated a grade and missed more school days. For example, >40% of food-insufficient teenagers had repeated a grade, as compared with 20.7% of food-sufficient teenagers.

Food-insufficient children and teenagers were also more likely to have psychosocial difficulties than those who were food-sufficient. For teenagers, these differences were dramatic: Food-insufficient teenagers were more than twice as likely to have seen a psychologist, almost 3 times as likely to have been suspended, almost twice as likely to have a lot or some difficulty getting along with others, and 4 times as likely to have no friends.

Regression Analyses

Results of the main effects regression analyses for the relationships between food insufficiency and the outcomes controlling for other characteristics are shown in Table 3. Coefficients and odds ratios for other variables in the models are shown in Appendix Tables 1–4. The main effect models showed that after adjusting for potential confounding variables, for 6- to 11-year-old children food insufficiency was significantly negatively associated with WRAT arithmetic scores and positively associated with having repeated a grade and seen a psychologist. Arithmetic scores were .40 points lower for food-insufficient children than for food-sufficient children. Food-insufficient children were 1.44 times more likely to have repeated a grade and 1.89 times more likely to have seen a psychologist. Food insufficiency was not significantly associated with cognitive outcomes, reading scores, and other psychosocial outcomes.

Food-insufficient teenagers were almost twice as likely to have seen a psychologist, have been suspended from school, and have difficulty getting along with other children as food-sufficient teenagers. Food insufficiency was not significantly related to any of the cognitive or academic outcomes.

The effect of food insufficiency for these outcomes was only slightly attenuated by the addition of health status in the model, which suggests that if the association between food insufficiency and the outcomes was causal, the effect of food insufficiency on

TABLE 2. Unadjusted Means and Prevalences of Cognitive, Academic, and Psychosocial Outcomes by Food Sufficiency Status for Children and Teenagers: NHANES III, 1988–1994

	Children: 6–11 years		Difference	Teenagers: 12–16 years		Difference
	Food-Insufficient (n = 372)	Food-Sufficient (n = 2911)		Food-Insufficient (n = 234)	Food-Sufficient (n = 1827)	
Cognitive outcomes						
Block Design (mean score)	8.5 (0.3)	9.8 (0.1)	−1.3**	8.0 (0.6)	9.3 (0.1)	−1.3**
Digit Span (mean score)	7.6 (0.4)	8.9 (0.1)	−1.3**	7.2 (0.4)	8.6 (0.1)	−1.4**
Academic outcomes						
Reading (mean score)	6.1 (0.4)	7.9 (0.1)	−1.8**	6.2 (0.4)	8.7 (0.2)	−2.5**
Arithmetic (mean score)	7.1 (0.4)	8.7 (0.1)	−1.6**	6.5 (0.5)	8.6 (0.2)	−2.1**
Repeated grade (%)	27.0 (4.3)	11.8 (1.3)	15.2**	41.6 (6.2)	20.7 (1.4)	20.9**
Days absent (mean)	6.2 (0.9)	4.7 (0.2)	1.5	12.9 (1.7)	7.7 (0.7)	5.2**
Psychosocial outcomes						
Seen psychologist (%)	16.7 (5.3)	10.0 (1.3)	6.7	35.4 (9.1)	14.7 (1.3)	20.7**
Ever suspended (%)	5.2 (1.6)	3.1 (0.7)	2.1	43.9 (8.4)	15.8 (1.2)	28.1**
How gets along with other children						
A lot of difficulty (%)	4.1 (1.4)	2.2 (0.5)	1.9	2.1 (0.9)	1.9 (0.4)	0.2
Some difficulty (%)	20.9 (3.3)	23.6 (1.5)	−2.7	38.1 (8.9)	21.4 (1.6)	16.7
No difficulty (%)	75.0 (3.5)	74.2 (1.3)	0.8	59.8 (8.7)	76.8 (1.7)	−17.0*
Number of good friends						
None (%)	2.6 (0.9)	3.0 (0.6)	−0.4	6.0 (2.5)	1.5 (0.3)	4.5*
1–2 (%)	25.9 (4.1)	25.3 (1.1)	0.6	29.8 (5.5)	23.5 (1.6)	6.3
3–5 (%)	44.8 (5.9)	43.9 (1.7)	0.9	43.1 (6.1)	41.1 (2.1)	2.0
6 or more (%)	26.7 (4.0)	27.8 (1.7)	−1.1	21.2 (5.3)	34.0 (2.0)	−12.9**
Making new friends						
Shy (%)	27.1 (4.4)	21.7 (1.0)	5.4	29.1 (5.4)	20.5 (1.4)	8.6
Average (%)	35.3 (3.8)	37.1 (1.6)	−1.8	33.9 (6.4)	41.7 (1.6)	−7.8
Outgoing (%)	37.7 (5.0)	41.3 (1.4)	−3.6	37.0 (7.4)	37.8 (1.5)	−0.8

Standard errors are listed in parentheses.
Significance is expressed as follows: * $P < .10$; ** $P < .05$.

TABLE 3. Coefficients and Odds Ratios for Food Insufficiency: NHANES III, 1988–1994

	6–11 Years		12–16 Years	
	Coefficient or OR*	P Value	Coefficient or OR†	P Value
Cognitive outcomes				
Block Design (C)	0.34	.12	−0.04	.91
Digit Span (C)	−0.06	.77	−0.14	.57
Academic outcomes				
Reading (C)‡	−0.13	.48	−0.01	.96
Arithmetic (C)‡	−0.40	.02	0.05	.85
Repeated grade (OR)‡	1.44	.02	1.34	.26
Days absent (C)	0.48	.46	0.04	.98
Psychosocial outcomes				
Seen psychologist (OR)	1.89	.02	1.82	.04
Ever suspended (OR)	0.99	.98	1.95	.00
Difficulty getting along with others (OR)	1.27	.12	1.74	.03
Fewer friends (OR)	0.86	.33	1.27	.21
Shyness (OR)	1.07	.51	1.10	.63

C, coefficient for linear regression analyses; OR, odds ratio for logistic or ordinal logistic regression analyses.
* Coefficients and odds ratios are adjusted for age, gender, metropolitan region, poverty index ratio, race–ethnicity, family head education, family head employment status, marital status, crowded housing, number of family moves, health insurance, regular source of health care, mother's age at child's birth, low birth weight, prenatal smoke exposure, birth complications, child care, height, blood lead concentration, and health status.
† Coefficients and odds ratios are adjusted for age, gender, metropolitan region, PIR, race–ethnicity, family head education, family head employment status, marital status, crowded housing, number of family moves, health insurance, regular source of health care, child care, height, blood lead concentration, and health status.
‡ Coefficients and odds ratios are also adjusted for Block Design score and Digit Span score.

these outcomes did not act primarily through diminished health status (see Appendix Tables 1–4).

Risk Factor Indices

Food insufficiency is not the only risk factor many American children face. The number of risk factors a child had was plotted against his or her academic, cognitive, and psychosocial outcomes (Fig 1 as an example). With increasing numbers of risk factors, 6- to 11-year-old children's WISC and WRAT scores decreased (Fig 1), and their odds of negative academic and psychosocial outcomes increased (data

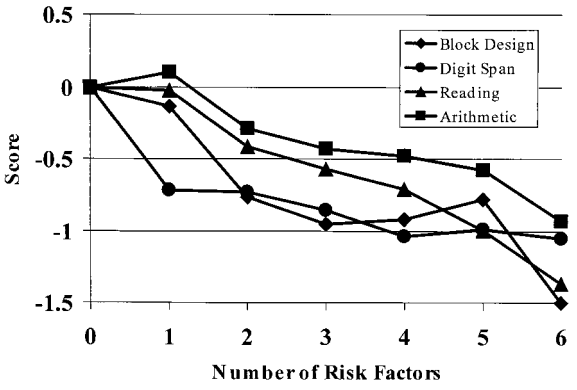

Fig 1. Relationship between number of risk factors and cognitive and academic outcomes: 6- to 11-year-old children

not shown). For teenagers, WISC and WRAT scores also decreased with increasing number of risk factors, but there was no clear relationship between number of risk factors and psychosocial outcomes (data not shown).

Stratified Analyses

The risk indices were used to divide children and teenagers into 2 groups: lower risk (0–2 risks) and higher risk (3 or more risks). Table 4 shows the coefficients and odds ratios by food insufficiency status for cognitive, academic, and psychosocial outcomes in the 2 groups. In the younger children, both arithmetic and reading scores were lower in food-insufficient children in the lower-risk group but not in the higher-risk group. Food-insufficient children were more likely to have repeated a grade in both the lower- and higher-risk groups, but the odds ratio was larger in the lower-risk group (2.12 vs 1.41). Food insufficiency was not related to block or digit scores or to number of school days lost in either the lower- or higher-risk groups. Higher-risk food-insufficient children were more likely to have seen a psychologist, but the odds ratios for these outcomes were similar in the lower-risk group. Higher-risk 6- to 11-year-old children were also more likely to have difficulty getting along with other children ($P < .10$).

For the teenagers, food-insufficient children did not have significantly lower WRAT or WISC scores in either the lower- or higher-risk groups, except for lower digit scores in the higher-risk group ($-.50$; $P < .10$). However, lower-risk food-insufficient teenagers were more likely to have problems in all psychosocial outcomes except shyness. Both lower- and higher-risk groups of food-insufficient teenagers were more likely to have been suspended from school, but the odds ratio for the lower-risk food-insufficient children was higher than for the higher-risk food-insufficient children (2.40 vs 1.87).

DISCUSSION

The results of this study demonstrate that family food insufficiency is associated with school-aged children's academic and psychosocial development. They support the growing body of research on the negative consequences of food insecurity and hunger for American children. Studies that have evaluated the effects of US nutrition programs, such as the Special Supplemental Food Program for Women, Infants and Children, Head Start, and the School Lunch and Breakfast Programs,[42–45] have shown small but significant benefits of food supplementation in cognition, academic achievement, and school absence. In addition, a positive relationship between some measure of nutritional status (such as dietary intake or height) and cognition or achievement has been found in most cross-sectional studies conducted in the United States.[15,46–52] Most recently, in 2 studies that used data from the Community Childhood Hunger Identification Project surveys, investigators found significant associations between being hungry or at risk of hunger and psychosocial and academic outcomes.[7,8]

TABLE 4. Coefficients and Odds Ratios for Food Insufficiency by Lower- and Higher-Risk Groups

	6–11 Years				12–16 Years			
	Lower Risk (0–2 Risks)		Higher Risk (≥3 Risks)		Lower Risk (0–2 Risks)		Higher Risk (≥3 Risks)	
	Coefficient*	*P* Value	Coefficient*	*P* Value	Coefficient*	*P* Value	Coefficient*	*P* Value
Cognitive outcomes								
Block Design	0.15	0.74	0.27	.29	0.28	0.65	−0.20	.57
Digit Span	−0.56	0.25	−0.05	.79	0.40	0.40	−0.50	.08
Academic outcomes								
Reading†	−1.24	0.01	0.17	.50	−0.56	0.21	0.21	.34
Arithmetic†	−0.99	0.01	−0.19	.39	−0.22	0.68	0.06	.87
Repeated grade (OR)†	2.12	0.07	1.41	.05	2.06	0.13	1.14	.63
Days absent	−0.11	0.86	1.12	.20	1.18	0.41	0.02	.99
	OR*	*P* Value	OR*	*P* Value	OR*	*P* Value	OR*	*P* Value
Psychosocial outcomes								
Seen psychologist	1.82	0.26	2.08	.03	2.83	0.01	1.73	.18
Ever suspended	2.35	0.13	0.79	.53	2.40	0.03	1.87	.05
Difficulty getting along with others	1.08	0.76	1.35	.09	2.66	0.01	1.37	.25
Fewer friends	0.64	0.10	1.01	.94	2.15	0.06	0.98	.93
Shyness	1.10	0.67	0.85	.18	1.30	0.35	1.05	.85

* Coefficients and odds ratios are adjusted for age, gender, metropolitan region, poverty index ratio, race–ethnicity, family head education, and height.
† Coefficients and odds ratios are also adjusted for Block Design score and Digit Span score.

The results reported here are important because they are the first to demonstrate an association between a questionnaire-based measure of family food insufficiency and negative developmental outcomes in a national sample of school-aged children. Furthermore, these results demonstrate that food insufficiency is associated with negative outcomes even after adjusting for many other factors that are known to place children's development at risk. Questionnaire-based measures of food insufficiency, food insecurity, or hunger are more appropriate than anthropometric measures for recognizing a relationship between current resource-constrained food deprivation and negative outcomes because they capture the phenomena of interest directly rather than through indirect indicators. For example, an indicator that has been used in previous research, child's height, is a better measure of past rather than current nutrition deprivation and is significantly influenced by other factors such as genetics. The NHANES III food insufficiency questionnaire was a precursor to the new Food Insecurity and Hunger scale developed in the mid-1990s by the US Department of Agriculture in collaboration with other federal agencies, advocacy groups, and university researchers. The Food Insecurity and Hunger questionnaire has been fielded annually since 1995 as part of the Current Population Survey. It is hoped that future research on the outcomes of food insecurity and hunger in the United States will use all or a portion of this questionnaire.[1,53]

Research on children's cognitive and psychosocial development suggests that developmental problems do not have single causes, nor do risks have specific outcomes, but rather that risk factors are additive and the more risks a child has, the worse the outcomes of all types.[20,35–39,54] Therefore, specificity of risk factors is less important than the total number of risks present. Our results support this hypothesis by demonstrating that each additional risk increases the likelihood that a child will have poorer outcomes. Studies of this nature have not typically included poor nutrition or food deprivation as risk variables. The results of our study illustrate that family food insufficiency is another risk factor that should be considered.

The regression analyses stratified by risk level revealed associations not previously detected, such as the association between food insufficiency and lower reading scores in children with fewer other risk factors. Furthermore, these analyses revealed that for some (but not all) academic and psychosocial outcomes, food insufficiency was more strongly associated with poorer outcomes in children with fewer other risk factors. The implications of these findings are not that it is unimportant to ensure that higher-risk children receive enough food but rather that food insufficiency may not be the only challenge some children face; ensuring food sufficiency without addressing other risk factors may not lead to measurable improvements. On the other hand, for children and teenagers with fewer other risk factors, providing their families with food alone may improve some academic and psychosocial outcomes.

Several limitations are associated with using the NHANES III survey. First, although the richness of NHANES III allowed us to delineate the relationship between food insufficiency and academic and psychosocial outcomes after adjusting for many other known risk factors, there are several important risk factors that we could not include in our analyses. For example, duration of poverty, school and neighborhood influences, personality traits of the child, and parental characteristics have been demonstrated to be associated with children's development.[14,55] In addition, because the NHANES III is a cross-sectional survey, it is not possible to determine how the various factors we identified to be associated with poor outcomes in children interacted in causal sequences. Finally, the NHANES III sample excluded homeless children and thereby excluded a significant portion of food-insufficient children in the United States.

The negative outcomes associated with family food insufficiency can be serious both for children as they are experiencing problems and for the adults they will grow to be. Parker and Asher[56] have found that having problems getting along with other children is a risk factor for later difficulties such as criminality and dropping out of school. In addition, low academic achievement in younger ages and grade failure is a predictor of low long-term education achievement and later behavior problems.[57]

Given that food insufficiency is associated with children's academic and psychosocial development, what are the potential mechanisms for this process? Although family food insufficiency has previously been associated with poorer health in children,[22] this study showed that health status as measured here is an unlikely mediating factor because adding health status to the regression models did not notably diminish the association between food insufficiency and any of the outcomes. However, it is possible that the general health status measure we used did not capture the aspect of health that is associated with both food insufficiency and poor developmental outcomes.

Another possibility is that going without food causes irritability, distractibility, or emotional changes, which in turn affect children's achievement scores or psychosocial behaviors. The results of experiments using animals suggest that food deprivation causes emotional responses to stressful events such as decreased motivation, selective attention, or cognitive inflexibility, which in turn affect how well animals learn.[4] This is relevant for children because, as Strupp and Levitsky explain,[4(p 2222S)] "it would unquestionably affect an individual's life if, for example, she/he is more easily frustrated, more anxious, or adapts less well to stressful situations."

Food is fundamental, and food insufficiency can also be likened to other material deprivations such as homelessness.[58–63] The absence of basic family necessities such as food or housing could cause anxiety and other emotional problems in children, even if the mechanism does not result from diminished nutrition status. Several studies have shown that homeless children are more likely than other low-income

children to be anxious and have behavior and academic functioning problems.[58–63]

Parents' stress and psychological impairment are among the strongest predictors of child developmental and psychological problems,[64–68] and another possible explanation is that family food insufficiency affects children through parental anxiety and parenting behavior. There is strong evidence that in food-insecure and hungry families in the United States, parents (most commonly mothers) deprive themselves of food before they allow their children to go hungry.[69–71] If this is the case, parental distress or irritability caused by a lack of food or the constant worry associated with not having enough food may affect children, even if the children are eating enough. Psychological impairment and harsh parenting have been found to occur in parents undergoing economic strain,[67,68,72] and family-level food insufficiency may be a better indicator of the family's material hardship and economic stress than family income.[73]

This does not mean that children who live in food-insufficient families necessarily have bad parents but rather that the stresses that accumulate on parents can affect how well they are able to care for their children. It makes sense that parents with more resources are better able to care for, support, and cherish their children. As Fitchen[70(p 224)] observed in a study of poor rural families, "the quality and quantity of mothering given to children was a barometer of how well or badly things were going on in the home at any given time." Garrett et al[74] and others[64,68] have found that "improvements in family income have the strongest effects on the quality of the home environment for children who were born poor or lived much of their lives in poverty."[74(p 331)]

Tackling only 1 problem will not ensure that all children in the United States enjoy a healthy childhood, but a key component of any child-centered policy should be ensuring that families have access to enough nutritionally adequate and safe food for an active, healthy life, including the ready availability of foods and the ability to acquire such foods in socially acceptable ways. The US government has stated its commitment to achieving food security through *Healthy People 2010*, which includes an objective to increase the food security of American households.[75] This research suggests that achieving this objective will benefit children.

ACKNOWLEDGMENTS

This research was supported by NIH Training Grant No. DK7158-24.

We thank Dr Kathleen Rasmussen for her critical review of this article.

REFERENCES

1. Hamilton W, Cook J, Thompson W, et al. *Household Food Security in the United States in 1995: Summary Report of the Food Security Measurement Project.* Alexandria, VA: US Department of Agriculture, Food and Consumer Service; 1997
2. US Bureau of the Census. *Poverty in the United States: 1998.* US Government Printing Office; 1999. Series P60-201
3. Pollitt E, Golub M, Gorman K, et al. A reconceptualization of the effects of undernutrition on children's biological, psychosocial, and behavioral development. *Soc Policy Rep*. 1996;10:1–21
4. Strupp B, Levitsky D. Enduring cognitive effects of early malnutrition: a theoretical reappraisal. *J Nutr*. 1995;125:2221S–2232S
5. Gorman K. Malnutrition and cognitive development: evidence from experimental/quasi-experimental studies among the mild-to-moderately malnourished. *J Nutr*. 1995;125:2239S–2262S
6. Wachs T. Relation of mild-to-moderate malnutrition to human development: correlational studies. *J Nutr*. 1995;125:2245S–2254S
7. Kleinman R, Murphy M, Little M, et al. Hunger in children in the United States: potential behavioral and emotional correlates. *Pediatrics*. 1998; 101(1). URL: http://www.pediatrics.org/cgi/content/full/101/1/e3
8. Murphy J, Wehler C, Pagano M, Little M, Kleinman R, Jellinek M. Relationship between hunger and psychosocial functioning in low-income American children. *J Am Acad Child Adolesc Psychiatry*. 1998;37: 163–170
9. National Center for Health Statistics. Plan and operation of the Third National Health and Nutrition Examination Survey: 1988–94. *Vital Health Stat*. 1994;1
10. Kramer R, Allen L, Gergen P. Health and social characteristics and children's cognitive functioning: results from a national cohort. *Am J Public Health*. 1995;85:312–318
11. Lagerstrom M, Bremme K, Eneroth P, Magnusson D. School performance and IQ-test scores at age 13 as related to birth weight and gestational age. *Scand J Psychol*. 1991;32:316–324
12. McGaughy P, Starfield B, Alexander C, Ensminger M. Social environment and vulnerability of low birth weight children: a social-epidemiological perspective. *Pediatrics*. 1991;88:943–953
13. Martin S, Ramey C, Ramey S. The prevention of intellectual impairment in children of impoverished families: findings of a randomized trial of educational day care. *Am J Public Health*. 1990;80:844–847
14. Korenman S, Miller J, Sjaastad J. *Long-Term Poverty and Child Development in the United States: Results From the NLSY*. Institute for Research on Poverty Discussion Paper 1044-94. University of Wisconsin; 1994
15. Edwards L, Grossman M. The relationship between children's health and intellectual development. In: Mushkin S, ed. *Health: What Is It Worth? Measures of Health Benefits*. New York, NY: Pergamon; 1980: 270–313
16. Crooks D. American children at risk: poverty and its consequences for children's health, growth, and school achievement. *Yearbook of Physical Anthropology*. 1995;38:57–86
17. Caughy O, DiPeitro J, Strobino D. Day-care participation as a protective factor in the cognitive development of low-income children. *Pediatrics*. 1994;65:457–471
18. Brooks-Gunn J, Gross R, Kraemer H, Spiker D, Shapiro S. Enhancing the cognitive outcomes of low birth weight, premature infants: for whom is the intervention most effective? *Pediatrics*. 1992;89:1209–1215
19. Alaimo K, Briefel R, Frongillo EA Jr, Olson C. Food insufficiency exists in the United States: results from the Third National Health and Nutrition Examination Survey (NHANES III). *Am J Public Health*. 1998;88: 419–426
20. Sameroff A. Environmental risk factors in infancy. *Pediatrics*. 1998;102: 1287–92
21. Sexton M, Fox N, Hebel J. Prenatal exposure to tobacco: II. Effects on cognitive functioning at age three. *Int J Epidemiol*. 1990;19:72–77
22. Alaimo K, Olson CM, Frongillo EA Jr, Briefel RR. Food insufficiency, family income, and health in US preschool and school-aged children. *Am J Public Health* 2001;91:781–786
23. Wechsler D. *Manual for the Wechsler Intelligence Scale for Children–Revised.* San Antonio, TX: Psychological Corp; 1974
24. Kaufman A. *Intelligence Testing with the WISC-R*. New York, NY: Wiley; 1979
25. Jastak S, Wilkinson G. *The Wide Range Achievement Test–Revised: Administration Manual*. Wilmington, DE: Jastak Associates; 1984
26. US Department of Health and Human Services. Poverty income guidelines; annual revision. *Federal Register*. 1995;60:7772–7774
27. Alaimo K. *Food Insecurity, Hunger, and Food Insufficiency in the United States: Cognitive Testing of Questionnaire Items and Prevalence Estimates from the Third National Health and Nutrition Examination Survey.* Ithaca, NY: Cornell University; 1997. Thesis
28. Alaimo K, Olson C, Frongillo E. Importance of cognitive testing for survey items: an example from food security questionnaires. *J Nutr Educ*. 1999;31:269–275
29. Briefel R, Woteki C. Development of the food sufficiency questions for the Third National Health and Nutrition Examination Survey. *J Nutr Educ*. 1992;24:24S–28S
30. Carlson S, Briefel R. The USDA and NHANES food sufficiency question as an indicator of hunger and food insecurity. *Conference on Food Security Measurement and Research: Papers and Proceedings*. Alexandria, VA: USDA, Food and Consumer Services; 1995

31. Findlay J, Greene B, Petty-Martin C, et al. *NHANES III Interviewer Debriefing, October 19–20.* Bethesda, MD: National Center for Health Statistics; 1994
32. Christofar S, Basiotis P. Dietary intakes and selected characteristics of women ages 19–50 years and their children ages 1–5 years by reported perception of food sufficiency. *J Nutr Educ*. 1992;24:53–58
33. Basiotis P. Validity of the self-reported food sufficiency status item in the US Department of Agriculture Food Consumption Surveys. *Proceedings, 1992 Annual Meeting of the American Council in the Consumer Interest*, Toronto, Ontario, Canada; March 1992:25–28
34. Rose D, Oliveira V. Nutrient intakes of individuals from food-insufficient households in the United States. *Am J Public Health*. 1997; 87:1956–1961
35. Sameroff A, Seifer R, Barocas R, Zax M, Greenspan S. Intelligence quotient scores of 4-year-old children: social-environmental risk factors. *Pediatrics*. 1987;79:343–350
36. Sameroff A. Environmental context of child development. *J Pediatr*. 1986;109:192–200
37. Seifer R, Sameroff A, Baldwin C, Baldwin A. Child and family factors that ameliorate risk between 4 and 13 years of age. *J Am Acad Child Adolesc Psychiatry*. 1992;31:893–903
38. Williams S, Anderson J, McGee R, Silva P. Risk factors for behavioral and emotional disorder in preadolescent children. *J Am Acad Child Adolesc Psychiatry*. 1990;29:413–419
39. Rutter M. Isle of Wright revisited: twenty-five years of child psychiatric epidemiology. *J Am Acad Child Adolesc Psychiatry*. 1989;28:633–653
40. Statacorp. *Stata Statistical Software. Release 5.0.* College Station, TX: Stata Corporation; 1997
41. Box G, Cox D. An analysis of transformations. *J R Stat Soc*. 1964;Series B 26:211–243
42. Geitzen D, Vermeersch J. Health status and school achievement of children from Head Start and Free School Lunch Programs. *Public Health Rep*. 1980;95:362–368
43. Hicks L, Langham R, Takenaka J. Cognitive and health measures following early nutritional supplementation: a sibling study. *Am J Public Health*. 1982;72:1110–1118
44. Meyers A, Sampson A, Weitzman M, et al. School breakfast program and school performance. *Am J Dis Child*. 1989;143:1234–1239
45. Rush D, Leighton J, Sloan N, et al. VI. Study of infants and children. *Am J Clin Nutr*. 1988;48:484–511
46. Douglas J, Ross J, Simpson H. The relation between height and measured educational ability in school children of the same social class, family size and stage of sexual development. *Hum Biol*. 1965;37:178–186
47. Humphreys L, Dvey T, Park R. Longitudinal correlation analysis of standing height and intelligence. *Child Dev*. 1985;31:1465–1478
48. Karp R, Martin R, Sewell T, et al. Growth and academic achievement in inner-city kindergarten children. *Clin Pediatr*. 1992;31:336–340
49. Richards G, Marshall R, Kreuser I. Effect of stature on school performance. *J Pediatr*. 1985;6:81–82
50. Pollitt E, Mueller W, Leibel R. The relation of growth to cognition in a well-nourished preschool population. *Child Dev*. 1982;53:1157–1163
51. Thatcher R, McAlaster R, Lester ML, et al. Comparisons among EEG, hair minerals and diet predictions of reading performance in children. *Ann N Y Acad Sci*. 1984;433:87–96
52. Wilson D, Hammer L, Duncan P, et al. Growth and intellectual development. *Pediatrics*. 1986;78:646–650
53. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the Household Food Security Scale. *Am J Public Health*. 1999;89:1231–1234
54. Sameroff A, Seifer R, Baldwin A, Baldwin C. Stability of intelligence from preschool to adolescence: the influence of social and family risk factors. *Child Dev*. 1993;64:80–97
55. Duncan J, Brooks-Gunn J. *Consequences of Growing Up Poor*. New York, NY: Russell Sage Foundation; 1997
56. Parker J, Asher S. Peer relations and later personal adjustment: are low-accepted children at risk? *Psychol Bull*. 1987;102:357–389
57. Baydar N, Brooks-Gunn J, Furstenberg F. Early warning signs of functional illiteracy: predictors in childhood and adolescence. *Child Dev*. 1993;64:815–829
58. Mayer S, Jencks C. Poverty and the distribution of material hardship. *J Hum Resources*. 1988;24:88–111
59. Menke E, Wagner J. A comparative study of homeless, previously homeless, and never homeless school-aged children's health. *Issues Compr Pediatr Nurs*. 1997;20:153–173
60. Bassuk E, Rosenberg L. Psychosocial characteristics of homeless children and children with homes. *Pediatrics*. 1990;85:257–261
61. Bassuk E, Weinreb L, Dawson R, Perloff J, Buckner J. Determinants of behavior in homeless and low-income housed preschool children. *Pediatrics*. 1997;1001:92–100
62. Buckner J, Bassuk E, Weinreb L, Brooks M. Homelessness and its relation to the mental health and behavior of low-income school-age children. *Dev Psychol*. 1999;35:246–257
63. Ziesemer C, Marcoux L, Marwell BE. Homeless children: are they different from other low-income children? *Soc Work*. 1994;39:658–668
64. Brody G, Stoneman Z, Flor D, McCrary C, Hastings L, Conyers O. Financial resources, parent psychological functioning, parent co-giving, and early adolescent competence in rural two-parent African American families. *Child Dev*. 1994;65:590–605
65. Dodge K, Pettit G, Bates J. Socialization mediators of the relation between socioeconomic status and child conduct problems. *Child Dev*. 1994;65:649–665
66. Holohan C, Moos R. Risk, resistance, and psychological distress: a longitudinal analysis with adults and children. *J Abnorm Psychol*. 1987; 96:3–13
67. McLoyd V, Jayaratne T, Ceballo R, Borquez J. Unemployment and work interruption among African American single mothers: effects on parenting and adolescent socioemotional functioning. *Child Dev*. 1994;65: 562–589
68. McLoyd V. The impact of economic hardship on black families and their children: psychological distress, parenting, and socioemotional development. *Child Dev*. 1990;61:311–346
69. Radimer KL, Olson CM, Campbell CC. Development of indicators to assess hunger. *J Nutr*. 1990;120 Suppl 11:1544–1548
70. Fitchen J. *Poverty in Rural America: A Case Study*. Boulder, CO: Westview; 1981
71. Devault M. *Feeding the Family: The Social Organization of Caring as Gendered Work*. Chicago, IL: University of Chicago Press; 1991
72. Conger R, Conger K, Elder G. Family economic hardship and adolescent adjustment: mediating and moderating processes. In: Duncan G, Brooks-Gunn J, eds. *Consequences of Growing Up Poor*. New York, NY: Russell Sage Foundation; 1997
73. Rose D. Economic determinants and dietary consequences of food insecurity in the United States. *J Nutr*. 1999;129:517–520
74. Garrett P, Ng'andu N, Ferron J. Poverty experiences of young children and the quality of their home environment. *Child Dev*. 1994;65:331–345
75. US Department of Health and Human Services, Office of Disease Prevention and Health Promotion. *Healthy People 2010: Understanding and Improving Health.* Washington, DC: US Department of Health and Human Services; 2000

APPENDIX TABLE 1. Regression Models for Cognitive and Academic Outcomes for Children Ages 6–11 Years, NHANES III, 1988–1994

	Cognitive Outcomes				Academic Outcomes							
	Block Design		Digit Span		Reading		Arithmetic		Repeated Grade		Days Absent	
	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	OR	*P* Value	Coefficient	*P* Value
Age	−0.08	.26	−0.05	.51	0.44	.00	−0.07	.34	1.60	.00	−0.17	.42
Male	0.63	.00	−0.42	.00	−0.58	.00	−0.53	.00	1.76	.00	−0.32	.25
Metropolitan area	0.19	.32	−0.09	.53	−0.14	.37	0.04	.81	0.85	.29	0.21	.57
Poverty index ratio	0.29	.00	0.18	.01	0.19	.01	0.17	.03	0.77	.00	−0.23	.16
Race–ethnicity												
Non-Hispanic black	−1.95	.00	−0.31	.06	−0.21	.16	−0.10	.53	1.09	.69	−1.71	.00
Mexican American, English	−0.16	.44	−0.53	.02	0.11	.56	0.11	.60	0.78	.29	−0.26	.62
Mexican American, Spanish	−0.30	.39	−1.26	.00	−0.46	.14	0.32	.23	0.61	.06	−0.62	.34
Family head education	0.14	.00	0.13	.00	0.05	.03	0.03	.24	0.99	.69	0.04	.45
Family head unemployed	0.19	.25	0.11	.54	−0.17	.27	−0.04	.82	1.09	.61	0.47	.19
Single parent	−0.16	.31	−0.10	.49	−0.40	.02	−0.27	.09	1.24	.22	0.47	.18
Crowded housing	−0.53	.03	−0.31	.04	−0.71	.00	0.12	.44	1.01	.95	0.07	.91
Number of family moves	0.20	.01	−0.03	.73	−0.03	.73	−0.02	.76	1.10	.28	0.15	.37
No health insurance	0.04	.83	0.20	.22	−0.58	.02	−0.45	.01	1.20	.29	−0.64	.32
No regular health care	−0.01	.97	0.24	.32	−0.24	.36	0.01	.95	0.96	.78	−0.24	.73
Mother's age at birth <18 y	−0.22	.38	−0.40	.11	0.11	.63	−0.05	.74	1.26	.27	0.86	.18
Low birth weight	−0.57	.02	−0.27	.28	−0.21	.39	−0.22	.29	1.01	.97	0.41	.48
Prenatal smoke exposure	−0.59	.00	−0.28	.05	−0.11	.49	−0.17	.14	1.18	.33	0.50	.06
Birth complications	−0.12	.53	−0.28	.20	−0.25	.20	−0.28	.16	1.73	.01	0.80	.10
No child care	−0.49	.00	−0.29	.02	−0.01	.92	0.05	.73	1.13	.43	0.07	.86
Height	0.00	.73	0.01	.58	0.03	.00	0.03	.00	0.98	.00	0.00	.92
Blood lead level (mg/dL)	−0.10	.00	−0.06	.00	−0.07	.01	−0.08	.00	1.03	.08	0.23	.04
Block Design score					0.17	.00	0.24	.00	0.94	.00		
Digit Span score					0.42	.00	0.39	.00	0.82	.00		
Food-insufficient	0.29	.18	−0.12	.58	−0.15	.43	−0.41	.02	1.48	.02	0.67	.31
Health status*	0.27	.00	0.28	.00	0.09	.18	0.05	.47	0.88	.13	−1.21	.00
Food-insufficient*	0.34	.12	−0.06	.77	−0.13	.48	−0.40	.02	1.44	.02	0.48	.46

Coefficients and odds ratios are adjusted for all other variables except health status.
* Coefficients and odds ratios are adjusted for all other variables plus health status.

APPENDIX TABLE 2. Regression Models for Psychosocial Outcomes: Children Ages 6–11 Years, NHANES III, 1988–1994

	Seen Psychologist		Ever Suspended		Difficulty Getting Along		Fewer Friends		Shyness	
	OR	*P* Value	OR	*P* Value	OR	*P* Value	OR	*P* Value	OR	*P* Value
Age	1.06	.52	1.43	.00	0.96	.44	0.97	.54	0.95	.16
Male	1.82	.00	5.64	.00	1.35	.01	1.25	.00	0.96	.65
Metropolitan area	1.22	.36	1.76	.06	0.94	.64	1.26	.03	1.13	.05
Poverty index ratio	1.09	.50	0.72	.02	0.92	.26	1.07	.20	1.02	.64
Race–ethnicity										
Non-Hispanic black	0.57	.03	2.98	.01	0.74	.04	1.25	.13	0.77	.03
Mexican American, English	0.33	.00	1.31	.59	0.48	.00	1.36	.02	0.98	.83
Mexican American, Spanish	0.63	.25	0.77	.68	0.65	.04	2.15	.00	1.28	.12
Family head education	1.03	.38	1.02	.69	1.00	.95	0.98	.27	1.00	.97
Family head unemployed	1.23	.45	0.84	.61	0.75	.06	0.97	.82	0.90	.29
Single parent	1.70	.01	1.30	.26	1.35	.01	1.08	.65	1.23	.02
Crowded housing	0.98	.92	1.58	.04	0.88	.34	1.29	.07	1.42	.00
Number of family moves	1.17	.05	0.97	.84	0.99	.82	1.01	.85	1.01	.91
No health insurance	0.81	.45	1.22	.58	1.01	.92	0.83	.16	1.25	.08
No regular health care	0.77	.30	1.50	.20	1.31	.16	1.45	.01	1.06	.63
Mother age at birth <18 y	1.12	.71	1.06	.86	1.03	.88	1.19	.10	0.68	.04
Low birth weight	1.29	.41	1.30	.33	1.06	.76	0.93	.70	1.11	.57
Prenatal smoke exposure	1.77	.00	1.30	.28	1.79	.00	1.07	.62	0.96	.69
Birth complications	1.27	.31	1.36	.21	1.22	.18	0.95	.68	1.10	.53
No child care	0.69	.00	0.90	.63	0.89	.24	1.22	.08	1.46	.00
Height	1.02	.16	1.01	.56	1.00	.58	1.00	.57	1.01	.04
Blood lead level (mg/dL)	1.02	.53	1.04	.12	0.99	.43	0.99	.49	0.99	.58
Food-insufficient	1.93	.02	0.99	.96	1.29	.09	0.87	.38	1.08	.45
Health status*	0.91	.34	1.08	.55	0.91	.08	0.90	.03	0.92	.08
Food-insufficient*	1.89	.02	0.99	.98	1.27	.12	0.86	.33	1.07	.51

Coefficients and odds ratios are adjusted for all other variables except health status.
* Coefficients and odds ratios are adjusted for all other variables plus health status.

APPENDIX TABLE 3. Regression Models for Cognitive and Academic Outcomes: Teenagers Ages 12–16 Years, NHANES III, 1988–1994

	Cognitive Outcomes				Academic Outcomes							
	Block Design		Digit Span		Reading		Arithmetic		Repeated Grade		Days Absent	
	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	OR	*P* Value	Coefficient	*P* Value
Age	−0.15	.03	−0.27	.00	−0.30	.00	−0.20	.01	1.14	.01	2.23	.00
Male	0.57	.00	−0.37	.05	−0.28	.08	−0.37	.04	1.71	.00	0.27	.78
Metropolitan area	0.44	.03	0.26	.06	−0.06	.78	−0.04	.85	0.85	.29	1.62	.18
Poverty index ratio	0.27	.00	0.22	.02	0.37	.00	0.32	.00	0.76	.00	−0.50	.28
Race–ethnicity												
Non-Hispanic black	−2.56	.00	−0.94	.00	−0.50	.01	−0.44	.03	1.10	.56	−3.66	.00
Mexican American, English	0.09	.63	−0.71	.00	0.22	.38	−0.29	.23	0.91	.59	−0.65	.77
Mexican American, Spanish	−0.58	.06	−1.28	.00	−0.51	.18	0.25	.40	0.51	.02	−4.54	.13
Family head education	0.10	.01	0.09	.00	0.10	.00	0.13	.00	0.95	.04	−0.40	.12
Family head unemployed	−0.26	.23	0.01	.98	0.31	.12	−0.27	.19	0.95	.80	4.18	.02
Single parent	−0.02	.91	−0.08	.66	−0.24	.19	−0.40	.04	1.03	.86	2.97	.02
Crowded housing	−0.44	.04	−0.16	.36	−0.28	.14	0.04	.84	0.67	.02	−2.43	.21
Number of family moves	0.06	.51	−0.10	.21	0.01	.88	0.05	.56	1.11	.09	0.82	.08
No health insurance	−0.18	.37	−0.31	.12	−0.26	.26	−0.31	.12	0.77	.18	3.62	.12
No regular health care	0.15	.46	−0.09	.70	−0.32	.08	−0.14	.37	1.01	.94	1.55	.46
No child care	0.21	.26	0.02	.90	0.08	.59	0.02	.90	0.83	.25	−0.72	.43
Height	0.03	.00	0.03	.00	0.02	.02	0.03	.02	0.99	.49	−0.05	.21
Blood lead level (mg/dL)	−0.07	.04	−0.07	.06	−0.04	.15	−0.10	.01	1.08	.03	0.24	.29
Block Design score					0.24	.00	0.31	.00	0.96	.02		
Digit Span score					0.47	.00	0.35	.00	0.85	.00		
Food-insufficient	−0.05	.88	−0.15	.53	−0.02	.92	0.04	.89	1.35	.26	0.18	.91
Health status*	0.20	.01	0.24	.00	0.20	.02	0.26	.00	0.81	.00	−1.94	.00
Food-insufficient*	−0.04	.91	−0.14	.57	−0.01	.96	0.05	.85	1.34	.26	0.04	.98

Coefficients and odds ratios are adjusted for all other variables except health status.
* Coefficients and odds ratios are adjusted for all other variables plus health status.