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Reprinted from
Economic Development and Cultural Change
Vol. 39, No. 2, January 1991

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1776 Massachusetts Avenue
Washington, D.C. 20036-1998

Reprint No. 203

Determinants of the Nutrition and Health Status of Preschool Children: An Analysis with Longitudinal Data*

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Introduction

Preschool children are usually considered one of the groups at greatest nutritional risk.[1] Malnutrition affects the rate of morbidity and mortality among the young and aiso poses a threat to their physical and mental development. Preschool children account for a disproportionately large share of the deaths in most developing countries. Nutritional deprivation is either directly or indirectly associated with most of those deaths. The very young are less able to cope physiologically with nutritional deficiencies than older children and adults. In addition, children who suffer a loss of growth due to early nutritional deprivation have only a limited capacity to overcome the resulting stunting. For these reasons, there is particular interest in the determinants of the nutrition and health status of preschool children in developing countries.[2]

The data used in this analysis are from household surveys carried out in three rural provinces of the Philippines in 1983–84 by the Philippine National Nutrition Council, the Ministry of Agriculture, and the International Food Policy Research Institute.[3] The surveys were conducted to evaluate a pilot food price subsidy program that was purposely tested in areas with high rates of poverty and malnutrition. The data were collected in four separate survey rounds spaced across 18 months from May 1983 to October 1984. The same, approximately 800, households were surveyed in each survey round. The data are, therefore, longitudinal (a panel) with both time-series and cross-sectional variation.

0013-0079/91/3902-0007$01.00

The surveys collected information on household size and composition, expenditures and food consumption, earnings by source and individual, and time allocation of the husband and wife. Anthropometric data (weights and heights) were obtained for all children less than 7 years old in the surveyed households. Individual food consumption data for a 24-hour period were collected for all household members in a subsample of 140 households in each of the four survey rounds.

This study estimates reduced-form equations for the nutrition and health status of preschool children (25–83 months of age). The nutrition indicator used is the child's calorie adequacy ratio. The anthropometric measurements of health (nutritional) status utilized are the child's *z*-score of height for age (stunting) and weight for height (wasting), which are indicators of the child's long-run (chronic) and short-run (current) health status, respectively. Many economists prefer to use the term "health status," rather than "nutritional status," in relation to such anthropometric measures.[4] An excellent survey of the work by economists on health and nutrition is provided by J. Behrman and A. Deolalikar.[5]

Two estimating models are utilized to take full advantage of the longitudinal data. In the first model, the observations for a given child across the various survey rounds were averaged and regressions run with the variable means. This model examines between-child variation and allows an analysis of time-invariant determinants. A fixed-effects model was also estimated, based on the differences in a particular survey round from the child-specific means for each variable. This model analyzes the within-child variation and eliminates the effect of unobserved community, household, and individual factors, including genetic endowment, which are time-invariant, and therefore removes potential biases in the estimates. Only a few studies on nutrition and health have controlled for such fixed effects, particularly individual factors, since longitudinal data are required.[6] The explanatory variables used include the child's birth order, wage rates, the price of two major food staples, and the food-price subsidy program. The results add to a growing literature concerning the effects of such factors on nutrition and health and are important to the design of programs and policies to reduce malnutrition and improve the health of children.

Analytical Framework

This section first outlines the derivation of reduced-form equations for calorie consumption and health status from a theoretical model of the household. The two estimating models applied to the longitudinal data are then discussed.

Theoretical Model

As is now common in the literature, the reduced-form equations for food consumption and health status can be derived from a multiperson household model that encompasses household production and consumption decisions.[7] A household behaves as if maximizing a joint utility function:

$$U = U(H, L, F, Z). \tag{1}$$

Given n family members, H, L, F, and Z are $1 \times n$ vectors of the health status H^i, leisure L^i, food consumption F^i, and nonfood consumption Z^i for every family member i. Because good health is desirable in itself and od is consumed for reasons other than its nutrient value, both appear directly in the utility function.

Health is a household-produced commodity. The health production function for the ith child is:

$$H^i = H(F^i, T^i, C^i, D^i, G^i, U^i), \tag{2}$$

where H^i is the health of the ith child as indicated by weight and height measurements, F^i is that child's food consumption. T^i is a vector of the child-care time inputs of other family members which affect the ith child's health, C^i is a vector of the ith child's observable characteristics, such as age and gender, D^i is a vector of the observed personal characteristics of the child's parents, such as their age and education, G^i is a vector of observed household characteristics, such as household size and location, and U^i is a vector of unobserved attributes of the child, parents, household, and community which affect the ith child's health status, for example, the child's genetic endowment, the parents' weight and height, which were not measured, and unobserved household and community sanitation factors.[8] The maximization of (1) subject to (2) and the usual full-income constraint, which combines both the time and budget constraints for household members, leads to the following reduced-form equations for the ith child's health (height and weight) and food consumption (calorie adequacy ratio):

$$H^i, F^i = f^j(C, D, G, U, W, P, V), \qquad j = H^i, F^i, \tag{3}$$

where C, D, G, and U are previously defined, W is market wage rates for household members, P represents a vector of food and nonfood prices, and V is the household's nonlabor income.[9] The same reduced-form relations in (3) can also be obtained from a household bargaining model.[10]

Estimation Procedure

In the first estimating model the observations for a given child were averaged across the survey rounds available.[11] A number of children were not included in some survey rounds. Some infants who were not old enough initially were 25 months or older in later survey rounds.

Other children who initially were included were over 84 months old in later rounds and thus excluded. And in some cases, children were simply absent from the household when the enumerators made their visit. Forty-five percent of the children appeared in all four survey rounds, 17% in three, 23% in two, and 15% in only one.[12]

Weighted-least-squares (WLS) regressions were run with the averaged variables because averaging introduces heteroscedasticity, since the number of survey rounds varies by individual. The square root of the number of survey rounds for that child was used as the weighting factor.[13] To simply pool the observations and apply ordinary least squares (OLS) would ignore the possible correlation of the error terms for a given individual and would overstate the number of independent observations in the sample. Averaging the observations by individual and applying WLS to the averaged variables addresses this issue and also reduces the impact of measurement error on the regressors.[14]

The basic time series–cross section model assumed in this approach can be specified as:

$$H^{it}, F^{it} = X^{it}\beta^{j} + \epsilon^{itj}, \qquad j = H^{i}, F^{i}, \tag{4}$$

where X represents all the exogenous explanatory variables, the superscript i denotes the child, and the superscipt t denotes the survey round. The first estimation procedure leads to the following specification:

$$\frac{\overline{H}^{i}}{\sqrt{m}}, \frac{\overline{F}^{i}}{\sqrt{m}} = \frac{\overline{X}^{i}\beta^{j}}{\sqrt{m}} + \frac{\overline{\epsilon}^{ij}}{\sqrt{m}}, \qquad j = H^{i}, F^{i}, \tag{5}$$

where m equals the number of survey rounds for a given child.

With this longitudinal data, the opportunity exists to remove the possible bias introduced by unmeasured or unobservable, time-invariant factors, which might be correlated with the included explanatory variables. The basic time series–cross section model would then be specified as:

$$H^{it}, F^{it} = X^{it}\beta^{j} + U^{i} + \epsilon^{itj}, \qquad j = H^{i}, F^{i}, \tag{6}$$

where U^{i} is the individual-specific effect. If U^{i} is viewed as an unknown but fixed factor differing across individuals, then the so-called fixed-effects model is the appropriate estimation procedure.[15] The variable (U^{i}) encompasses community fixed effects, such as environmental factors, and household fixed effects, such as housing and water supply, plus child-specific factors, such as genetic endowment. The fixed-effects model is obtained by transforming the variables into deviations from the individual averages:

$$(H^{it} - \overline{H}^{i}), (F^{it} - \overline{F}^{i}) = (X^{it} - \overline{X}^{i})\,\beta^{j} + (\epsilon^{itj} - \overline{\epsilon}^{ij}),\quad j = H^{i}, F^{i}. \tag{7}$$

Since the U^i terms are fixed, they drop out of the model, and unbiased and consistent estimates are obtained using OLS. This model serves as a remedy for the effects of all time-invariant omitted variables. However, the problem of measurement error is likely to be more serious due to the differencing involved.[16] For the estimation of the fixed-effects model, children with only one survey round of data were excluded. Those exogenous variables that were completely, or basically, time-invariant were dropped from the fixed-effects analysis.[17]

Data and Variables

This section describes the variables used in the empirical analysis, starting with the dependent variables. The basic descriptive statistics are given in table 1, along with a description of each variable. Infants less than 2 years old (under 25 months) were excluded from the analysis, since different factors may affect their health status, and many Filipino infants are breast-fed up to about 24 months. Breast feeding would need to be incorporated into the model for infants.

Dependent Variables

A food-weighing method was utilized to obtain food consumption data for a 24-hour period for individuals in the subsample of households. Information on meals and snacks eaten outside the household was collected by recall, with the mother responding for young children. The calorie content of each child's diet was determined using Philippine food-composition tables for the various foods consumed. The adequacy ratio was calculated using the recommended daily allowances (RDAs) for calories developed by the Philippine Food and Nutrition Research Institute for Filipinos.[18] The RDAs are not individual-specific but are specified for age and gender categories.

The average calorie adequacy ratio for the children (25–83 months) in the sample was 64%. In comparison, the calorie adequacy ratio for all individuals in the survey households was 70%, and the national average for the Philippines was 89%.[19] These figures are consistent with the purposeful selection of areas of high malnutrition, particularly among preschool children, for the pilot food subsidy program.

The anthropometric measurements used as indicators of nutritional status are the z-scores of height for age and weight for height. The standard deviation or z-score method is recommended by the World Health Organization (WHO).[20] As recommended by the WHO, the National Center for Health Statistics data for U.S. children were used as the growth standards for the reference population.[21]

TABLE 1

VARIABLES AND DESCRIPTIVE STATISTICS

Variables	Mean	Standard Deviation
Dependent variables:		
Calorie adequacy ratio (%) (calorie consumption/ recommended daily allowance for calories)	64.29	23.66
z-score of height for age	−2.03	1.83
z-score of weight for height	−.54	1.54
Child-related variables:		
Age in months	49.35	18.75
Gender (1 if male, 0 if female)*	.50	
Birth order	3.33	2.63
Father and mother variables:		
Father's age in years	36.18	9.86
Mother's age in years	32.59	8.73
Father's education in years	6.88	4.49
Mother's education in years	7.42	4.40
Men's wage rate in 1978 pesos per hour	3.04	2.55
Women's wage rate in 1978 pesos per hour	3.15	4.62
Household variables:		
Household size (number of persons)	6.72	2.61
Price of rice in 1978 pesos per kilogram	2.86	.42
Price of cooking oil in 1978 pesos per kilogram	19.08	19.34
Value of the food subsidy for rice and cooking oil in 1978 pesos per week	2.98	4.31
Antique province (1 if in province, 0 otherwise)	.43	. . .
South Cotabato province (1 if in province, 0 otherwise)	.29	. . .

NOTE.—The data relate to children 25–83 months old and are from the same sample of 1,191 used in the regressions in table 3, except for the calorie adequacy ratio, which is from the sample of 222.

* For the dummy variables, the zero and one observations were averaged, and the mean indicates the proportion of observations with a value of one.

A rule of thumb for evaluating anthropometric z-scores has been developed, with a score of less than −3.00 indicating "severe" malnutrition, between −3.00 and −2.01 "moderate" malnutrition, −2.00 to −1.01 "mild" malnutrition, and −1.00 and above considered normal.[22] The results for this breakdown are given in table 2 for the preschool children in the survey. In part A of table 2, the figures are from the pooled data in which the original data from each survey round for each child are the observations. In part B, the observations for each child from the various survey rounds were first averaged before the figures were calculated.

The results in table 2 clearly indicate a population in which malnutrition among preschool children is a very serious problem, particularly in terms of stunting. As one would expect, averaging the observations for each child smooths out some of the more extreme observations,

TABLE 2

z-SCORE CLASSIFICATION OF HEALTH STATUS OF CHILDREN 25–83 MONTHS

z-SCORE CATEGORIES	DEGREE OF MALNUTRITION	PERCENTAGE OF SAMPLE BY z-SCORE CATEGORY	
		Height/Age	Weight/Height
A. Original data:			
Below −3.00	Severe	23.0	10.3
−3.00 to −2.01	Moderate	27.1	8.7
−2.00 to −1.01	Mild	24.7	20.0
−1.00 and above	Normal	25.1	60.9
B. Averaged data:			
Below −3.00	Severe	23.5	3.5
−3.00 to −2.01	Moderate	27.0	8.2
−2.00 to −1.01	Mild	25.9	24.5
−1.00 and above	Normal	23.6	63.8

particularly in terms of weight for height, the current health (nutritional) status indicator. The major difference between the results in parts A and B is that the proportion of children with "severe" wasting is reduced by over two-thirds by averaging the observations.

Independent Variables

The first set of exogenous variables shown in table 1 is related to the individual child and includes the child's age in months, gender, and birth order. A strong relationship has been observed in previous studies between age and gender and the child's nutrient intake and health status.[23] Recent work has shown that the child's birth order may also have a substantial impact on nutrition and health.[24] Higher-birth-order children can suffer due to the increased strain on family resources, particularly in terms of the time available for child care. The birth-order variable used in this analysis is for surviving children and starts with one for the oldest child, increasing by one for each additional child.

In the second category of independent variables, fathers in the sample were slightly older than mothers. However, the mothers had completed slightly more schooling on average than the fathers. The parents' ages and education levels, particularly the mother's, might be expected to have a positive impact on preschooler nutrient intake and health status.[25] One can hypothesize that older and better-educated parents would have improved child-rearing skills.

Village-level rather than individual wage rates were used, since the latter may depend on a person's calorie intake and health status.[26] Individual wages are thus endogenous, and their use would introduce simultaneity bias. However, village-level wages were not gathered in the study. The surveys collected time allocation data for husbands (fathers) and wives (mothers), which could be combined with the individual earnings data to calculate market wage rates for those individuals who were employed in the labor force. These individual wages were then used to obtain average wage rates by village for each survey round.

Surprisingly, the average wage for women in table 1 is slightly higher than that for men. The similarity of men's and women's wages which has been noted before for the Philippines may be largely explained by the equal access of girls to schooling in the Philippines, which is reflected in the average education level of the parents.[27] Furthermore, only 14% of the wives in the sample were in the labor force, and many of them were employed in higher-paying occupations, such as school teaching. The only women who held jobs in the labor force were those whose market wage was higher than their reservation wage, which reflected their productivity in household activities. Of the 55% of husbands employed in the labor force, many held low-paying jobs, such as laborer, which reflected their relatively low reservation wage for nonmarket activity.

Since time, and particularly the mother's time, is an input into the household production of nutrients and health, the prior hypothesis would be that the wage effects will be negative. However, wage rates either in the context of a joint household utility function or a household bargaining model may also have an effect on the intrahousehold distribution of resources, in which case the effect of wages on child nutrition and health might be positive or negative.[28]

Most households were nuclear families, a husband and wife and their children, with an average of seven persons. Prices for two major staples, rice and cooking oil, were included as explanatory variables. Price data were collected in the household surveys and reflect both spatial variation across the three widely separated regions included in the study and variation across the four survey rounds. As with wages, prices were deflated by the Consumer Price Index with a base year of 1978. Numerous previous studies have found the impact of food prices on nutrient intake and health status to be weak, or even positive, because of strong substitution effects among foods.[29]

The households in some villages received both a rice and a cooking oil subsidy; in some, only cooking oil was subsidized. Several villages received no subsidy, and these served as a control group. The initial price subsidy was 32% for rice and 50% for cooking oil. Since not all the households surveyed participated in the pilot food subsidy scheme, the mean given in table 1 understates the value to those that did. The weekly value in 1978 pesos averaged 5.34 pesos for those households that received a subsidy. The subsidy may be treated as exogenous, since in those villages in which households were eligible virtually all participated, and the amount of the subsidy was determined by family size, which is viewed as predetermined.[30] Since the first survey round was conducted prior to the initiation of the food subsidy and the fourth round after it was discontinued, the food subsidy value may be included as a variable in the fixed-effects model. The impact of the subsidy was extensively analyzed by M. Garcia and P. Pinstrup-Andersen.[31]

The three provinces in which the study was conducted were Abra, Antique, and South Cotabato Abra is an upland tobacco and subsistence corn area, located in northern Luzon, the major island of the Philippines. Antique is a coastal fishing and marginal rice-farming area, located in the middle of the island archipelago. South Cotabato is a river basin primarily devoted to corn production and is located on the southern island of Mindanao.

Empirical Results

This section discusses the regression results for the reduced-form equations for calorie consumption (measured in terms of the calorie adequacy ratio) and health status (as indicated by height for age and weight for height). Table 3 gives the results for the WLS regressions in which the observations for each child were averaged across the available survey rounds. Table 4 provides the results for the fixed-effects model, in which the observations were deviations from the child-specific means for each variable. Tables 3 and 4 give the estimated coefficients and *t*-statistics and indicate whether a variable is statistically significant at a 10% or 5% level.

The discussion of the results in tables 3 and 4 is combined and precedes in the order of the variables in table 3. The child's age does not have a statistically significant impact in any of the WLS regressions in table 3. This may be due to the relatively narrow age range (25–83 months) of children in the sample. The results in table 4 reveal, however, that when unobserved fixed effects are removed, both long-run and short-run health status improves with age. As has been observed previously, malnutrition is frequently most serious in children just after weaning.[32]

The child's gender has a positive effect on the calorie adequacy ratio but a negative impact on height for age. Boys receive a larger percentage of their RDA for calories but are more stunted in relationship to the height standard for their age than girls. The favoring of boys in the intrahousehold distribution of calories is consistent with the findings of previous studies, both specifically for the Philippines and for other countries.[33] The greater stunting among boys in this sample could be a reflection of the impact of other inputs into their

TABLE 3

WEIGHTED-LEAST-SQUARES REGRESSION RESULTS

Independent Variables	Calorie Adequacy Ratio	Height/Age	Weight/Height
Intercept	.510**	−2.11**	−1.53**
	(2.40)	(3.18)	(2.68)
Child's age	.001	−.001	.001
	(1.36)	(.22)	(.44)
Gender	.078**	−.241**	.016
	(3.24)	(3.02)	(.23)
Birth order	−.018	−.085**	.018
	(1.14)	(1.96)	(.49)
Father's age	−.0001	.026**	−.012*
	(.04)	(3.16)	(1.77)
Mother's age	.003	.002	.011
	(1.11)	(.22)	(1.22)
Father's education	−.002	.036**	−.012
	(.66)	(2.76)	(1.10)
Mother's education	.002	.051**	.005
	(.40)	(3.80)	(.46)
Men's wage	−.002	−.106**	−.009
	(.34)	(4.89)	(.48)
Women's wage	.001	.029**	−.039**
	(.27)	(2.27)	(3.49)
Household size	−.006	.012	−.017
	(.42)	(.33)	(.54)
Price of rice	−.013	−.401**	.479**
	(.22)	(2.16)	(3.01)
Price of cooking oil	.0005	.001	.002
	(.58)	(.47)	(.84)
Food subsidy value	.013**	.015	.030**
	(2.19)	(.91)	(2.13)
Antique	.085**	−.002	−.253**
	(2.16)	(.02)	(2.33)
South Cotabato	−.044	.387**	−.365**
	(1.28)	(3.36)	(3.69)
R^2	.23	.10	.06
F-ratio	3.99	8.28	5.09
Sample size	222	1,191	1,191

NOTE.—t-statistics are given in parentheses below the coefficients.
* Significant at the 10% level.
** Significant at the 5% level.

long-run health production function, which differs from that of girls. The growth norms used might also be less appropriate for Filipino boys than girls.

The long-run health status (height for age) of higher-birth-order children suffers, presumably due to the increased burden on family resources. In particular, higher-birth-order children probably receive less parental care and attention than their older siblings did at a similar age. S. Horton, with data for the Bicol region of the Philippines, also found that the adverse effects of birth order were substantially greater

TABLE 4

FIXED-EFFECTS MODEL REGRESSION RESULTS

Independent Variables	Calorie Adequacy Ratio	Height/Age	Weight/Height
Child's age	−.0004	.028**	.016**
	(.23)	(10.01)	(4.65)
Men's wage	−.004	−.022**	.010*
	(1.16)	(5.04)	(1.87)
Women's wage	.0004	−.003	.0003
	(.24)	(1.11)	(.08)
Household size	.064**	.039*	.001
	(3.31)	(1.71)	(.05)
Price of rice	.042	−.148**	.210**
	(1.48)	(3.18)	(3.72)
Price of cooking oil	−.001	.001	−.003**
	(1.53)	(1.28)	(2.79)
Food subsidy value	.008**	.0003	.013**
	(3.00)	(.09)	(3.17)
R^2	.05	[illegible]	.02
F-ratio	3.35	[illegible]	8.75
Sample size	498	2,611	2,611

NOTE.—t-statistics are given in parentheses below the coefficients.
* Significant at 10% level.
** Significant at 5% level.

on long-run health status than on current health status (weight for height). In table 3, birth order does not have a statistically significant effect on weight for height or the calorie adequacy ratio. Earlier-born (lower-birth-order) children also fared better in terms of their nutrition and health status in a study for south India.[34]

Father's age has a positive impact on the child's height for age and a negative effect on weight for height. The effect of the mother's age is not statistically significant, though. In previous studies, it has more typically been the mother's age that has an effect. Horton observed, using Philippine data, that the mother's age had a positive impact on the child's height for age.[35] The effect of father's age in table 3 may simply reflect the impact of unobserved fixed factors. The 18-month longitudinal dimension of the data was too short to include parental ages in the fixed-effects model.

Parental schooling appears to improve the child's long-run health status. The education levels of both the father and mother have a significant positive impact on height for age. Other studies, such as the early papers by J. Behrman and B. Wolfe with Nicaraguan data, have stressed the importance of the mother's schooling, in particular, as a determinant of the child's nutrient intake and health status.[36] There may, however, be certain parental attributes, such as ability and motivation, that are positively correlated with both their own education level and their children's health. Without controlling for such endowments, the impact of schooling may be overestimated. Because parental education levels are basically time-invariant, the possible impact of unobserved fixed effects could not be removed in our analysis. Wolfe and Behrman used a Nicaraguan sample of adult sisters to control for unobserved childhood background related characteristics of the mothers with adult-sister deviation estimates.[37] They found that the impact of mother's schooling on child health indicators was no longer significant. The impact on household nutrition, in terms of calorie and protein intake, was still substantial and significant, though.

In table 3, three of the coefficient estimates related to village-level wage rates are significant. Two are negative, but the effect of the women's wage on height for age is positive. The expected effect of wages would be negative if wages only represented the opportunity cost of time. However, previous studies that included wage rates also found the impact on nutrition and/or health to be positive in some cases.[38] Since reduced-form equations are estimated, a particular regression coefficient may intermix several structural effects. The parameter estimates for wages may reflect not only the impact of the value of time but possibly also a full-income and an intrahousehold distribution effect, both of which could be positive. In the latter case, individuals with higher actual or potential wages might have a greater influence on the intrahousehold allocation of food and other resources which affect nutrition and health.[39] Furthermore, the results for wages in table 3 may reflect unobserved fixed effects which are related to the village's general environment.

In table 4, women's wages no longer have a significant effect, which suggests they were serving as a proxy for certain unobserved endowments that affect child health status. Behrman and Deolalikar also found that the apparent significant effect of the wage rate for women on individual nutrition and health in a cross-section model with level variables was not present after correcting for fixed effects.[40] Men's wages still have a significant negative effect on height for age, and a positive and now significant impact on weight for height. These results may reflect a combination of underlying structural relations, so that a negative opportunity cost of time effect dominates in the one case, whereas a positive full-income and/or intrahousehold distribution effect prevails in the other. Additionally, there may be response lags that complicate the relationship, particularly when the effects of changes over relatively short time periods are evaluated, as in the 18 months covered by the fixed-effects estimates.

Household size has a significant positive impact in the calorie adequacy and height for age equations in table 4. Since the effect of time-invariant factors has been removed, household size is not acting as a possible proxy for unobserved fixed endowments. Because household full income is a function of wage rates and the number of economically active family members, this variable may be reflecting a full-income effect.

The price of rice has a significant negative impact on height for age and a significant positive effect on weight for height in both the WLS and fixed-effects equations. The coefficient for cooking oil is significant and negative in the fixed-effects regression for weight for height. The positive impact of the price of rice on current health status may seem surprising. However, such positive price effects have been obtained in a number of previous nutrition and health studies and can be explained by strong substitution effects between foods.[41]

Rice is the preferred staple in the Philippines, but it is a more costly source of calories than some of the inferior staples, such as corn and root crops like cassava. Short-run health status improves when the price of rice increases because the very poor households are forced to decrease their rice consumption and substitute more of the cheaper, inferior staples into their diets. However, the overall nutrient quality of rice is better than the inferior staples, and particularly its protein content is higher. Therefore, the growth of the children (height for age) suffers when rice prices rise, which explains the negative rice price coefficients in those equations. Although relatively expensive, cooking oil has an extremely high calorie density, which explains its negative price effect on weight for height in table 4.

The food subsidy has a positive and significant effect on both the calorie adequacy ratio and weight for height in table 3. This same pattern is confirmed in table 4, after the possible bias introduced by unobserved fixed effects is removed, and is particularly convincing evidence of the effectiveness of the food subsidy program. That the food subsidy had a substantial impact on the calorie intake and short-run health status of preschool children, but not on their long-run health (height for age), should perhaps not be unexpected, given the limited duration of the food subsidy program, which operated for approximately 1 year. The results concerning the food subsidy confirm and extend the earlier analysis of Garcia and Pinstrup-Andersen, which was more comprehensive but less methodologically oriented.[42]

The preschoolers in Antique receive a higher portion of their calorie RDA than in the other two regions, but at the same time they are thinner and suffer more wasting than in Abra. The children are taller for their age and suffer less stunting in South Cotabato than in the two other provinces, but they also weigh less in relation to their height and experience more wasting than in Abra.

In an overall appraisal of the results, the F-ratios indicate statistical significance at the 1% level or better for each of the six regressions in tables in 3 and 4. The small proportion of the variation in individual nutrient intake and health status which is explained by the regressions, as shown by the low R^2's, is quite typical of studies in this area.[43]

Usually less than 10% of the variation in individual health indicators can be explained; studies of nutrient and food demand normally have somewhat more explanatory power.[44] The coefficients of determination in table 4 are particularly low, which is not unexpected for first difference equations.

Conclusions

Effective policies and programs to alleviate malnutrition require an understanding of the underlying determinants. This study adds to the rapidly expanding literature that, in the last several years, has greatly increased our knowledge of the factors affecting nutrition and health status in developing countries. The complexity of the causal relationships has made this a challenging task. Earlier empirical studies, as well as this analysis, have been able to account for only a limited portion of the variance in nutrition and health status among individuals. Even so, "important information may be obtainable about the magnitude of critical responses, such as to prices or to policies."[45] A greater problem than the total explanatory power is the possibility of estimation bias due to factors such as simultaneity or omitted variables.

As in other studies, this analysis addressed the simultaneity issue by estimating reduced-form relationships. Reduced-form equations yield less information concerning the underlying structure, but can provide good estimates of the response of nutrient intake and health status to important exogenous factors, such as endowments, prices, and specific government policies and programs.

Two estimating models were used to take full advantage of the available longitudinal data. The weighted-least-squares regressions, in which the observations for a given child were averaged over survey rounds, reduce the element of measurement error and allow for the analysis of time-invariant factors. In addition, the multiple observations for an individual allow the utilization of a fixed-effects model that corrects for the possible impact of unobserved endowments and other omitted time-invariant factors, which might bias the estimates. Panel data with a longer longitudinal dimension than the 18 months available here would be desirable to provide greater variation in key variables.

Our results reinforce and extend the findings of previous research in this area. The child's age, gender, and birth order, as in other studies, were each found to be significant explanatory factors in certain of the nutrition and health relationships. Parental education has a positive impact on the long-run health status (height for age) of preschoolers. The importance of mother's schooling has been emphasized in earlier work, although the results may be biased by unobserved parental endowments. The exogenous, village-level wage rates for both men and women were significant determinants in the WLS health status regressions, but only those for men remained significant in the fixed-effects model. The impact of rice prices was negative on height for age but positive on weight for height. Such positive price effects are not uncommon in the literature and are the result of strong substitution effects among foods.

This study expands on and complements previous analyses of the impacts of the pilot food subsidy program and supplies strong evidence that the food subsidy was successful at improving the nutrition (calorie consumption) and current health status (weight for height) of preschoolers. Perhaps the most convincing proof comes from the fixed-effects equations. There is relatively little information in the literature linking food-price subsidy programs to nutrition and health outcomes.[46] The Philippine pilot food subsidy scheme deserves careful examination for lessons that may be learned concerning the design and implementation of nutrition intervention programs with the objective of reducing malnutrition among preschoolers.

Notes

* We wish to thank Henry Hwang at the University of Minnesota for his assistance with the computer work and also to acknowledge the two anonymous referees, whose constructive comments significantly improved the final version of this article.

1. For a discussion regarding malnutrition among preschool children and its implications, see James E. Austin, *Confronting Urban Malnutrition: The Design of Nutrition Programs*, World Bank Staff Occasional Paper no. 28 (Baltimore: Johns Hopkins University Press, 1980), pp. 14–15; Eileen Kennedy, "Analysis of the Determinants of Preschooler Nutritional Status" (International Food Policy Research Institute, Washington, D.C., March 11, 1983, mimeographed); and Reynaldo Martorell, "Nutrition and Health Status Indicators: Suggestions for Surveys of the Standard of Living in Developing Countries," World Bank Living Standard Measurement Study, Working Paper no. 13 (World Bank, Washington, D.C., February 1982), pp. 7 and 74.

2. A number of previous studies have analyzed the determinants of child nutrition and health status. Some of the most relevant to this study are Josephine R. Battad, "Nutritional Status of Preschoolers," *Philippine Economic Journal* 17 (1978): 154–67; Susan Horton, "Child Nutrition and Family Size: Results from the Philippines," *Journal of Development Economics* 27 (1986): 55–76, and "Birth Order and Child Nutritional Status: Evidence from the Philippines," *Economic Development and Cultural Change* 36 (January 1988): 341–54; John Strauss, "Households, Communities, and Preschool Children's Nutrition Outcomes: Evidence from Rural Côte d' Ivoire," *Economic Development and Cultural Change* 38 (January 1990): 231–62.

3. For a detailed description of the study areas, the pilot food subsidy program, and the survey methodology, see Marito Garcia and Per Pinstrup-Andersen, *The Pilot Food Price Scheme in the Philippines: Its Impact on Income, Food Consumption, and Nutritional Status*, Research Report no. 61 (International Food Policy Research Institute, Washington, D.C., August 1987).

4. See Jere R. Behrman, "Nutrition and Incomes: Tightly Wedded or Loosely Meshed?" (PEW/Cornell Lecture Series on Food and Nutrition Pol-

icy, Cornell University, October 4, 1988); Jere R. Behrman and Anil B. Deolalikar, "How Do Food Prices and Income Affect Individual Nutritional and Health Status? A Latent Variable Fixed-Effects Analysis" (University of Pennsylvania, April 11, 1988, mimeographed), hereafter cited as "Food Prices"; and "Health and Nutrition," in *Handbook of Development Economics*, ed. Hollis Chenery and T. N. Srinivasan (New York: North Holland, 1988), 1:631–711.

5. Behrman and Deolalikar, "Health and Nutrition."

6. Among the recent studies deriving fixed-effects estimates are Behrman and Deolalikar, "Food Prices"; Strauss; Jere R. Behrman and Anil B. Deolalikar, "The Intrahousehold Demand for Nutrients in Rural South India: Individual Estimates, Fixed Effects and Permanent Income," *Journal of Human Resources* (in press), hereafter cited as "Intrahousehold Demand"; and Mark M. Pitt, Mark R Rosenzweig, and Md. Nazmul Hassan, "Productivity, Health and Inequality in the Intrahousehold Distribution of Food in Low-Income Countries," Bulletin no. 89–1 (University of Minnesota, Economic Development Center, Minneapolis, February 1989).

7. Behrman, "Nutrition and Incomes"; Behrman and Deolalikar, "Food Prices," and "Health and Nutrition"; Strauss; and Mark M. Pitt and Mark R. Rosenzweig, "Health and Nutrient Consumption Across and Within Farm Households," *Review of Economics and Statistics* 67 (1985): 212–23.

8. A nutrient production function that relates nutrients to foods and other factors may also be introduced, rather than assuming that the nutrient-food conversion factors are constant across individuals or households. See Behrman and Deolalikar, "Food Prices," and "Health and Nutrition," p. 642.

9. For this study, the nutrient demand relation for calories is estimated directly rather than indirectly by deriving the effect on nutrients from a food demand system. The direct approach has certain advantages. The commodities included in demand systems are typically quite aggregate, so that much of the substitution that occurs between foods is eliminated. See Behrman and Deolalikar, "Health and Nutrition," pp. 675–79, and "Intrahousehold Demand."

10. Behrman and Deolalikar, "Food Prices," make this point. For a discussion of the bargaining model, see Marilyn Manser and Murray Brown, "Marriage and Household Decision-Making: A Bargaining Analysis," *International Economic Review* 21 (1980): 31–44; and Marjorie B. McElroy and Mary Jean Horney, "Nash-bargained Household Decisions: Towards a Generalization of the Theory of Demand," *International Economic Review* 22 (1981): 333–50.

11. For an overview of various estimation models for pooled cross-section/time-series data, see G. S. Maddala, *Econometrics* (New York: McGraw-Hill, 1977), pp. 320–33.

12. To check for possible sample selection bias, the mean *z*-scores of height for age and weight for height for each survey round were derived separately for children observed in that round and the other three rounds, in that round and two others, in that round and one other, and only in that survey round. This was done to check whether a child's health status was related to the number of survey rounds in which he/she was observed. The similarity of the means across the groups suggested that sample selection bias is not a problem. For example, the average *z*-scores of height for age of −2.06 and weight for height of −.62 for children with only one observation in any of the four survey rounds are quite comparable to the overall means in table 1 and also to the averages for children with four observations of −1.97 and −.54.

13. Maddala, p. 268.

14. One degree of freedom was lost for each child when the child means were calculated for each variable.

15. James A. Hausman, "Specification Tests in Econometrics," *Econometrica* 46 (November 1978): 1251–72.

16. Behrman and Deolalikar, "Food Prices," p. 10; and Zvi Griliches, "Sibling Models and Data in Economics: Beginnings of a Survey," *Journal of Political Economy* 87, no. 5 (1979): S37–S64.

17. Behrman and Deolalikar in two recent studies of nutrition and health ("Food Prices," and "Intrahousehold Demand") also use two estimating models to take full advantage of longitudinal (panel) data. They estimate both fixed effects equations and equations that pool the data across the various survey rounds, rather than deriving individual averages across rounds.

18. Virginia S. Claudio, Patrocenio E. DeGuzman, Moninia S. Oliveros, and Gemma P. Dimaamo, *Basic Nutrition for Filipinos* (Manila: Merriam Corp., 1982).

19. Benjamin Senauer, Marito Garcia, and Elizabeth Jacinto, "Determinants of the Intrahousehold Allocation of Food in the Rural Philippines," *American Journal of Agricultural Economics* 70 (February 1988): 170–80.

20. World Health Organization, *Measuring Change in Nutritional Status* (Geneva, 1983). In particular, the problem with the old method of just using the percentage in relation to the reference population median values is that they are not equivalent for different ages and anthropometric measures. The specific formula for the z-scores is:

$$z\text{-score} = \frac{\left[\text{child's anthropometric value} - \text{median value of the reference population}\right]}{\text{standard deviation of reference population median}}.$$

21. World Health Organization, *Measurement of Nutritional Impact*, WHO document no. FAP/79.1 (Geneva, November 1979). Martorell (p. 43) and Kennedy (p. 13) defend the use of growth data for children in developed countries as norms for developing countries. In comparisons of well-nourished preschool children from diverse ethnic groups, the anthropometric differences are quite small, especially compared to the very large differences within ethnic groups between malnourished and well-nourished children.

22. Horton, "Child Nutrition and Family Size."

23. Behrman and Deolalikar, "Food Prices," and "Health and Nutrition" (both in n. 4 above), and "Intrahousehold Demand."

24. Horton, "Birth Order and Child Nutritional Status"; and Jere R. Behrman, "Nutrition, Health, Birth Order and Seasonality," *Journal of Development Economics* 28 (1988): 43–62.

25. Jere R. Behrman and Barbara L. Wolfe, "More Evidence on Nutrition Demand: Income Seems Overrated and Women's Schooling Underemphasized," *Journal of Development Economics* 14 (1984): 105–28; and Barbara L. Wolfe and Jere R. Behrman, "Determinants of Child Mortality, Health and Nutrition in a Developing Country," *Journal of Development Economics* 11 (1982): 163–93.

26. Behrman and Deolalikar, "Food Prices," and "Health and Nutrition"; and Strauss (n. 2 above).

27. See Battad (n. 2 above); Senauer, Garcia, and Jacinto; Robert E. Evenson, Barry M. Popkin, and Elizabeth K. Quizon, "Nutrition, Work and

Demographic Behavior in Rural Philippine Households," in *Rural Household Studies in Asia*, ed. Hans P. Binswanger, Robert E. Evenson, Cecilia A. Florencio, and Benjamin N. F. White (Singapore: Singapore University Press, 1980), pp. 289–364; Raul V. Fabella, "Economies of Scale in the Household Production Model and Intra-Family Allocation of Resources" (Ph.D. diss., Yale University, 1982); and Alejandro N. Herrin, "Female Work Participation and Fertility in a Philippine Setting: A Test of Alternative Models," Discussion Paper no. 8005 (University of the Philippines, School of Economics, October 1980).

28. See Manser and Brown (n. 10 above); also McElroy and Horney (n. 10 above) for the theory; and Senauer, Garcia, and Jacinto for an empirical application.

29. Behrman, "Nutrition and Incomes" (n. 4 above); Behrman and Deolalikar, "Food Prices," "Health and Nutrition," and "Intrahousehold Demand"; and Jere R. Behrman, Anil B. Deolalikar, and Barbara L. Wolfe, "Nutrients: Impacts and Determinants," *World Bank Economic Review* 2, no. 3 (1988): 299–320.

30. A major problem in past studies on the impact of food subsidies is the possible bias due to sample self-selection. In this study, self-selection was removed because all households in the subsidized areas participated in the subsidy scheme, while households in the nonsubsidized areas acted as a control group.

31. Garcia and Pinstrup-Andersen (n. 3 above).

32. See John S. Akin, Charles C. Griffin, David K. Guilkey, and Barry M. Popkin, "Determinants of Infant Feeding: A Household Production Approach," *Economic Development and Cultural Change* 33 (1985): 57–81; also Strauss (n. 2 above), p. 13.

33. See Senauer, Garcia, and Jacinto (n. 19 above); also Alice Stewart Carloni, "Sex Disparities in the Distribution of Food within Rural Households," *Food and Nutrition* 7 (1981): 3–12; also U.S. Department of Agriculture, Nutrition Economics Group, Office of International Cooperation and Development, "Intra-Family Food Distribution: Review of the Literature and Policy Implications" (Washington, D.C., August 1983).

34. Horton, "Birth Order and Child Nutritional Status" (n. 2 above); Behrman, "Nutrition, Health, Birth Order and Seasonality" (n. 24 above).

35. Horton, "Child Nutrition and Family Size" (n. 2 above).

36. Behrman and Wolfe; Wolfe and Behrman, "Determinants of Child Mortality, Health and Nutrition in a Developing Country."

37. Behrman and Deolalikar, "Health and Nutrition," pp. 665 and 669; and Barbara L. Wolfe and Jere R. Behrman, "Women's Schooling and Children's Health: Are the Effects Robust with Adult Sibling Control for Women's Childhood Background?" *Journal of Health Economics* 6, no. 3 (1987): 239–54.

38. Behrman and Deolalikar, "Food Prices" (n. 4 above), "Health and Nutrition" (n. 4 above), p. 661, and "Intrahousehold Demand" (n. 6 above); Strauss (n. 2 above); and D. M. Blau, "A Model of Child Nutrition, Fertility, and Women's Time Allocation: The Case of Nicaragua," in *Research in Population Economics*, ed. T. P. Schultz and Ken Wolpin (Greenwich, Conn.: JAI Press, 1984).

39. Manser and Brown (n. 10 above); McElroy and Horney (n. 10 above); and Senauer, Garcia, and Jacinto (n. 19 above).

40. Behrman and Deolalikar, "Food Prices."

41. Ibid., Behrman and Deolalikar, "Health and Nutrition," p. 664, and "Intrahousehold Demand"; and Pitt and Rosenzweig (n. 7 above).

42. Garcia and Pinstrup-Andersen (n. 3 above).

43. Averaging the data, as in the analysis for the results in table 3, tends to increase the R^2 value; Jan Kmenta, *Elements of Econometrics* (New York: MacMillan, 1971), p. 327.

44. Behrman and Deolalikar, "Health and Nutrition," p. 660.

45. Ibid.

46. Ibid., pp. 692–96; and Per Pinstrup-Andersen, ed., *Food Subsidies in Developing Countries: Costs, Benefits and Policy Options* (Baltimore: Johns Hopkins University Press, 1988).