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DETERMINANTS OF CHILD HEALTH, MORTALITY, AND NUTRITION IN A DEVELOPING COUNTRY

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ABSTRACT

Child health and nutrition status are important determinants of adult productivities and earnings; thus they represent an important channel of intergenerational socioeconomic mobility. Building upon economic models of household behavior, we investigate the determinants of child health, mortality and nutrition status in a developing country, and offer some policy suggestions.

Variables for health and mortality include weight, height, biceps and mortality measures for a sample of young children and their mothers in Nicaragua. Regions, distinguished by degree of urbanization, are considered; effects differ across regions. Income is not an important determinant, but (except for the relatively low-income rural areas) parental schooling is. The more children there are in a family, the poorer is child health and nutrition. Caloric intake is, of course, directly associated. As one would expect, also, specific commodities such as availability of refrigeration and the extent of public investments such as sewer systems have a positive association.

Determinants of Child Health, Mortality, and Nutrition in a Developing Country

INTRODUCTION

What determines child health, mortality and nutrition status in developing countries is a critical question, for a whole host of reasons. First, the levels of child health, mortality, and nutrition are important indexes of current socioeconomic welfare, and these levels are often low in developing countries. Second, the health and nutrition status of children significantly conditions the subsequent intelligence, health and nutrition status of adults; all of these have a direct impact on adult productivities, earnings and the quality of life.[1] Third, child health, mortality and nutrition status may be related to the level of such investments in children as education, and thereby have an indirect long-run impact on adult productivities and earnings.[2]

Fourth, these may be important intervening variables through which intergenerational socioeconomic mobility is limited. Parental education or income, for example, can affect a child's health and nutrition directly or indirectly (say, through the number of siblings), and this child's adult options may be directly or indirectly affected. Poverty may then be transmitted through such a channel. Fifth, in the United States, family income is relatively unimportant among those family characteristics that affect child health status, but parental education is important (Chernichovsky and Coate, 1979; Edwards and Grossman, 1978); do similar results hold for developing countries in which incomes are much lower? The answer may substantially assist policymakers in choosing policy interventions with the highest payoffs. Sixth, child mortality, which is higher in Latin America than in the more developed countries, because health interventions are currently less effective in reducing it than in reducing adult mortality (Merrick, 1979), has a feedback on fertility and overall child quality.[3] Better knowledge of the determinants of child mortality may shed some light on this process. Seventh, there is evidence for the United States that pre- and peri-natal care has an impact on child health, and through child health, on education, adult health, and adult productivity and earnings (Davis and Schoen, 1978). In order to evaluate the returns to improved pre- and peri-natal care in Latin America, some quantification of this link is useful. Eighth, many studies in the human capital tradition for developed countries, and some on developing countries (e.g., Blau, 1977) suggest that there is a quality-quantity trade-off for children. If this trade-off exists, improved child health may be asssociated with higher quality, and hence lowered fertility and lessened population pressure.

For all of these reasons, knowledge of the determinants of child health, mortality and nutrition status in developing countries is very important. But the current state of such knowledge is quite poor. In this paper, therefore, we present the results of our efforts to investigate this topic to the extent possible, using data we collected in a cross-sectional multipurpose survey of women of childbearing age in Nicaragua.[4] In Section 2 we present our a priori rationale for the specification of multivariate relations to determine child health and nutrition status. In Section 3 we introduce our data set and define the relevant variables. We present and discuss our multivariate estimates in Section 4, and conclude in Section 5.

MODEL SPECIFICATION

We build upon economic models of household behavior developed in the past two decades, placing a "Chicago-Columbia school" emphasis on the role of human capital, household production and the allocation of time, and a "Pennsylvania school" emphasis on intergenerational considerations, biological factors, imperfect knowledge and the endogeneity of tastes.[5]

We posit a household (parental) utility function (U)[6] which depends upon commodity consumption (Z), number of children (C), expected average full income of the children when they become adults (E), average child mortality (M), health (H) and nutrition status (N), and practices like breastfeeding, contraception and frequency of coition (B), all of which are conditional on <u>norms</u> concerning commodity consumption (Z^*), number of children (C^*), and practices like breastfeeding and frequency of coition (B^*):

$$U = U(Z, C, E, M, H, N, B; Z^*, C^*, B^*) \tag{1}$$

We need not discuss the standard inclusion of commodity consumption and number of children in this function. We follow the widespread practice of including the average characteristics of children, with the exception that we also consider sexual differences, in our empirical work below.[7]

We include expected average earnings of children, because we posit that parents are concerned about their children's adult prospects as well as their current welfare.[8] The former may be either a pure concern about intergenerational family welfare, or a concern about potential transfers from children to parents in the parents' old age, which are much more important in developing than in developed countries due to the relative inadequacies of capital markets and pension systems. We could reduce the number of arguments in the utility function with no impact on our empirical analysis by assuming that parents are concerned with average child characteristics only insofar as they affect expected average child earnings as adults, as some other studies do (Becker and Tomes, 1979; Behrman, Pollak and Taubman, 1980), but we think it useful to emphasize that current average child welfare may be a relevant factor even if we are not able to identify whether or not in fact it enters separately from expected average earnings in the utility function.[9] Even if we were to assume that average child health and nutrition status entered into household utility only through its impact on average expected adult earnings, we would think it useful to include child mortality separately as a reminder that there must be some disutility costs to such mortality, or infanticide would be much more widely practiced than it apparently is.

We include practices like breastfeeding, contraception and frequency of coition as a reminder that such practices do have costs and benefits. If there were no such costs, for example, abstinence would be the dominant method of contraception and there never would be excess children in a world of certainty (Easterlin, Pollak and Wachter, 1980). For purposes of the present study, breastfeeding is the most important of these practices which is observable.

We include various norms to emhasize that preferences are conditional upon them. Such norms may vary across communities or over time. Within the context of our particular empirical exploration, the specific implications of these norms are twofold: First, certain activities, such as schooling, may change these norms. Therefore, realistically, it may be difficult to identify whether such activities change efficiency in household production or change tastes. Second, it is widely hypothesized that reference norms differ among communities in developing countries depending on their degree of urbanization and modernization. Therefore it may be important to subdivide a national sample into subsamples by such criteria.

The household faces a number of constraints:

(1) The traditional budget constraint in which total monetary expenditures on goods and services (X) cannot exceed total earnings plus other inflows.

(2) The traditional time-budget constraints in which total time spent in paid labor force activities plus household production (including breast-feeding), etc., cannot exceed total time available for each individual. However, in developing countries the distinction between market and nonmarket activities is often fuzzier than in more developed countries. For example, a number of household activities, particularly child care, can be combined with market participation in the informal sector (Behrman and Wolfe, 1980h; Behrman, Wolfe and Tunali, 1980).

(3) The traditional market prices (W), including those for goods and services, child investments, labor dependent on skills, etc.

(4) A household production function in which commodities (Z) are produced by inputs of market-purchased goods and services (X) and time in efficiency units (T). The latter may depend upon skills and upon the extent to which market activities and household production are carried on simultaneously, as is fairly frequent in developing countries. Given sexual division of labor with women specializing in home production, the work conditions and skills of women may be more important than those of men (as Leibowitz, 1977, claims is the case for the United States).

(5) An average child's expected earnings function (E) which depends on various human capital investments, including those in average child health (H) and nutrition (N), and on average genetic endowments (G).

(6) A biological childbirth function that depends on parental commodity consumption (Z) and public environment considerations relating to sewage and water supplies and population densities (P) (as well as on genetics and earlier human capital investments in the parents). The function emphasizes parental health, fecundity status and parental practices such as the frequency of coition, contraceptive choice, and choices regarding such practices such as breastfeeding (B).

(7) Functions for biological child mortality (M), health (Y) and nutrition status (N) that depend upon average child genetic endowments (G), commodity consumption (Z), the public environment (P) and such parental practices as breastfeeding (B). In the production of commodities that enter into these functions, parental education may be particularly important under the plausible assumption that more educated parents tend to be more knowledgeable than those who are less educated about preventive and curative health and nutrition measures, more capable of following medical and nutritional advice or instructions, less fatalistic about illness and therefore more prone to seek medical help for a sick child, and more child-oriented due to the larger role mothers play in intrafamilial decisions (e.g., see Behm, 1979; Caldwell, 1979; and Cochrane, 1979).

(8) Expected average child earnings functions (E) that depend on investments in children (including their health and nutrition status) and their average genetic endowments.

(9) Parental skill functions which depend on their genetic endowments and various investments in them, including schooling(S).[10]

(10) Other adding-up constraints, such as the number of surviving children, which equals natality minus child mortality.

If parents perceive all of these constraints, they can maximize household utility with respect to all of them and determine optimal levels of child mortality (M), health (H) and nutrition status (N) with other simultaneous variables (e.g., Z, C, B, E). If parents only partially perceive the constraints due to what Easterlin, Pollak and Wachter (1980) term "unperceived jointness," they can maximize utility with respect to the constraints that they perceive, but in the process unknowingly determine outcomes for the other variables in the system. In either case, child mortality, health and nutrition status depend on all of the exogenous variables and parameters and forms of the constraints. However, if there is "unperceived jointness" for these variables as would seem to be more likely for the more traditional areas of developing countries, the incomplete nature of the maximization would lead to different results than with complete maximization. This is another reason that for empirical work it is preferable to subdivide a national sample into more and less traditional groups.

One could specify exact functional forms for the utility function and all the constraints and derive explicit solutions for the optimal levels of child mortality, health and nutrition status with either complete knowledge or any particular degree of unperceived jointness.[11] We do not here follow such a procedure for three reasons: (1) The choices of functional forms are somewhat arbitrary. (2) The analytical expressions which would result would be sufficiently complex that the signs of most partial derivatives would be indeterminate without very specific information not only about the general functional forms but also about the magnitudes of all of the parameters. (3) We do not have the data nor other required resources to estimate the complete system.

Instead, we proceed from this overall general framework to the estimation of simple reduced-form solutions for the child mortality, health and nutritional status variables of primary interest for this study. Our simple (generally linear) relations can be interpreted as local approximations to the more complex expressions which would result from maximization of the complete system (or some subset thereof) with explicit functional forms.[12]

In our specification, estimation and interpretation of these relations, we benefit from the above outline of the overall theoretical system in a number of respects: (1) The theoretical discussion suggests what variables should be included, if possible, in the estimated relations. (2) It also suggests that such relations may differ between more traditional versus more modern communities because of different norms, market prices and public environments, and degrees of unperceived jointness. Therefore subdivision of the sample may be desired. (3) It further implies that care must be taken in interpreting certain effects since some variables may alter the outcomes in a number of ways. For example, more schooling for the parents may alter outcomes through changing tastes or through changing efficiency in household production. However, parental schooling also may be serving partly as a proxy for genetic endowments. (4) Finally, this discussion suggests that in reduced-form estimates of the type that we are undertaking, disaggregation to particular fairly specific variables may be important because norms, market prices, and public environments may differ across the sample. For example, because of such differences, it may not suffice to include a proxy for aggregate commodity consumption alone. In addition it may be desirable to include specific representations of nutrient intakes, use of medical services, etc.

DATA

We conducted a stratified random survey of socioeconomic characteristics of women of childbearing ages (15-45) in the central metropolis, other urban, and rural areas of Nicaragua in 1977-1978. For 1,871 cases we have child mortality data. For 1,281 women we have health and nutrition status information on a randomly-selected child under 5 years of age. We now discuss our definitions for the variables which enter into the determination of average child mortality, health and nutrition status on the basis of the discussion in the previous section. We first consider the dependent variables and then the right-hand-side variables. In all cases we distinguish among the three regions noted above (i.e., central metropolis, other urban, and rural) due to probable differential (but unobservable) norms, prices, public endowments, and degrees of unperceived jointness. Table 1 gives the means and standard distributions for the relevant variables for the three regions and for the overall sample.

Dependent Variables

Child mortality. Our reported child mortality rates are 1.7% for the central metropolis, 6.3% for the other urban areas, and 8.5% for rural areas.[13] The inverse association with urbanization is not surprising

Table 1

Means and Standard Deviations of Regional Distributions of Variables Used in Analysis of Child Mortality, Health and Nutrition Status

Variables	Central Metropolis		Other Urban		Rural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Commodity consumption and income (100's of cordobas per fortnight)						
Other income	7.1	7.0	6.8	8.5	3.5	9.2
Woman's predicted income	2.2	1.8	2.0	1.7	0.9	0.6
Other factors in household production						
Woman's schooling (years)	5.3	3.2	5.2	3.8	1.3	1.9
Age (years)	27.8	6.5	28.2	6.6	29.0	6.8
Participation in informal sector[a]	.38	.49	.79	.41	.89	.32
Male companion present[a]	.88	.33	.85	.36	.86	.35
Schooling (years)	6.1	3.9	5.7	4.6	1.2	2.0
Household size	7.3	3.6	7.2	3.2	7.2	3.1
Births/year in five years	.39	.28	.43	.23	.50	.32
Nutrition-specific commodities						
Average caloric intake	.62	.15	.75	.17	.49	.16
Refrigeration[a]	.28	.45	.28	.45	.02	.15
Length of breastfeeding (months)	5.3	6.7	5.0	6.5	10.1	7.4
Public environment						
Sewers[a]	.75	.43	.30	.46	.03	.18
Population density (people/km^2)	72	41	172	321	59	71
Parasites[a]	.41	.49	.57	.50	.54	.50
Other variables and controls						
Male[a]	.48	.50	.48	.50	.46	.50
Never migrated[a]	.50	.50	.55	.50	.34	.48
Child's age (months)	26	17	35	16	40	15
Dependent child mortality, health, and nutrition variables						
Mortality[a]	.017	.13	.063	.24	.085	.27
Standardized weight	-.21	1.50	-.23	1.31	- .88	1.16
Standardized height	-.68	1.50	-.90	1.61	-1.87	1.55
Standardized biceps circumference	.96	.09	.95	.08	.91	.07

S.D. = Standard Deviation

[a]Dichotomous variables with value of one in indicated state; otherwise a value of zero.

given the positive association between urbanization and income, schooling, health care facilities, good water and sanitation. But the levels are low relative to other estimates. Probably they are underestimates because they are based on reported recall data. We expect in particular that deaths of very small infants may be underreported, so we control for child's age in our estimates below. Perhaps there is an inverse association between reporting such deaths and the respondent's education. If so, this would cause a bias towards zero in an estimate of the impact of women's education on the probability of child mortality. Also there may be cultural differences in regard to underreporting which are associated with the degree of modernization or urbanization. If so, this is another reason for subdividing our sample by the degree of urbanization.

Standard weight. To construct this variable we took the weight of the child (which we measured), subtracted the mean weight for a child of identical age and sex according to widely used international standards based on well-nourished United States children (National Center for Health Statistics, 1976), and divided the difference by the sex and age-specific standard deviation from the same international standards.[14] This measure (and the other two below) is not subject to the recall error that may contaminate the child mortality rates, although there probably is measurement error (which causes no bias if it is random). The use of the international norms gives a reference point based on a population in which malnutrition is not present. We use these norms because they control partially[15] for genetic age-sex patterns of child growth and because they facilitate comparison with other studies. The standard interpretation of the standardized weight measure is that it refers primarily to relatively current or short-run health and nutrition status, and not only to differences in genetic pools across populations (Blau, 1980; Edwards and Grossman, 1977 and 1978; Habicht et al., 1974; Zerfas et al., 1975).

For our three regions the mean values of the standardized weight measures are -.21, -.23, and -.88 (with standard deviations of 1.50, 1.31 and 1.16). Children in all three regions on the average tend to be below the U.S. standard, and more so in the rural than in the urban areas (although the dispersion is positively associated with the degree of urbanization). Thus short-run malnourishment is widespread in general, but more extensive in the rural areas. However there may be an interaction with age occurring, which underlies part of the higher average malnourishment in the (on the average, older) rural sample.

Standardized height. This variable is defined in a fashion parallel to that for the standardized weight, and similar comments apply. The standard interpretation of the standardized height measure is that it refers to relatively long-run or permanent health and nutrition status (Edwards and Grossman, 1977 and 1978; Ybarra Rojas, 1978). It assumes that potential height is the same across ethnic groups (Habicht et al., 1974).

For our three regions the mean values of the standardized height measures are -.68, -.90 and -1.87 (with standard deviations of 1.50, 1.61 and 1.55). Thus long-run malnourishment is prevalent in all three regions and is inversely associated with urbanization (although again there may be an interaction with age), but in this case without any increase in dispersion in the more urban areas. The standardized height measure of long-run nutritional status is significantly correlated with the short-run standardized weight measures (.7, .6, .7). However, these correlations indicate that there may be important differences between short- and long-run nutrition status since the variance in one measure is consistent with half or less of the variance in the other.

Standardized biceps circumference. This variable is standardized relative to the mean international value for a child of the identical age (Seoane and Latham, 1971). We use such a standardization to control for age since we do not have age-specific standard deviations of the international norms. The standard interpretation of the biceps measure is that it pertains to muscular development associated with relatively long-run or permanent health and nutrition status.

For our three regions the mean values of the standardized biceps circumference are .96, .95, and .91 (with standard deviations of .09, .08. and .07). In this case, as with the standardized weight measure, average nutrition is positively associated with urbanization (once again, with a possible age interaction), but the standard deviation is inversely related. The correlations of the standardized biceps measure with the standardized height measure (.7, .7, .6) are higher than are those with the standardized weight measure (.5, .4, .4). This is not surprising since both the standardized height and biceps measures supposedly represent long-run nutrition status, while the standardized weight measure supposedly represents short-run nutrition status. But note that the standardized biceps measure is even less correlated with the standardized weight measure than is the standardized height measure. Moreover, the correlations between the two long-run measures imply that one is consistent with less than half the variation in the other. Therefore, either measurement error is important or the different measures are referring to different dimensions of long-run nutritional status.

Right-Hand-Side Variables

Because of limitations of data we have to approximate some of the variables that the discussion of the previous section indicates are relevant. We do not have even proxies in other cases. We now discuss the variables which we use.

Commodity consumption (Z) and income. In the model of Section 2, both commodity consumption and income are endogenous variables. In our data set we have observations on income, but not on overall commodity consumption.

We treat income other than women's earnings ("other income") as an exogenous variable representing the generalized purchasing power that largely accounts for the market goods and services (X) that enter into the household production function. The largest component of this other income is earnings from male companions (Behrman, Wolfe and Blau, 1980; Wolfe, Behrman and Blau, 1980). The assumption of exogeneity in this case is not too troublesome since prime-age male participation rates are very high, hours worked are relatively fixed for males in comparison to females, and wages are determined by past human capital investments. The other two components of other income are income from assets and transfers. An important part of the latter in many cases is child support. The assumption of exogeneity also does not seem troublesome for these two categories, although some transfers could be in response to perceived needs in the form of child illness or malnutrition. The distributions across regions for other income have means that are about twice as high for the two urban areas as for the rural areas, while they have standard deviations that are inversely associated with the degree of urbanization.

If prices are constant across the regions, our rural sample is worse off than our urban ones in regard to both absolute and relative within-region income distribution.[16]

We do not use actual women's earnings in our income measure because women's labor force participation is far from universal and many women participate primarily or exclusively in nonpaid household production. Instead we use the woman's predicted earnings, as estimated from earnings functions with a control for selectivity in labor force participation (Behrman and Wolfe, 1980h; Behrman, Wolfe and Tunali, 1980; Tunali, Behrman, and Wolfe, 1980). This gives us a much better measure than would actual earnings of the relative contribution of women in our sample to household commodity production, whether it be entirely in direct household production or partly through goods and services purchased by earnings from women's paid labor market activities. This estimate also lessens the possibility of confounding earnings with breastfeeding in the multivariate context; actual earnings may be inversely associated with breastfeeding, since the latter normally is not practiced while working at high-earning jobs.[17] We include predicted women's earnings separately from other income because of the difference in definition. Across regions, predicted women's earnings tend to be much higher in the urban than in the rural areas, both because of the regional distribution of women's human capital and because of geographically segmented labor markets (Behrman and Wolfe, 1980h). In contrast to the distributions for other income, however, the dispersion in the distributions of women's predicted earnings is much lower in the rural than in the urban areas.

Other factors in household production. We include other factors related to efficiency in household production and the time available on a per child base.

We suggest above that more educated women may be more efficient in household production. Therefore we include the woman's schooling as a separate variable to see if there are any added efficiency effects beyond those captured in the predicted earnings variable. We remind the reader, however, that this variable may be representing in part differential norms or genetic endowments. Across the regions, the big disparity in the distributions of women's schooling is between the two urban areas on one hand and the rural on the other, with means of 5.3, 5.2 and 1.3 years.

Women may become more efficient in household production with general experience and maturity. Therefore we also include the woman's age as a factor. The distributions of age do not vary much across regions, although there is a slight inverse association between urbanization and mean ages (27.8, 28.2 and 29.0 years). There is a fair amount of variance, however, within each region.

A third factor which is important regarding the women's contribution to household production is the sector in which she works if she participates in the paid labor force. As we note above, women working in the informal sector generally can combine their paid-labor participation with at least the child-care component of household production.[18] Across regions, the proportions of working women in the informal sector are inversely associated with urbanization (.38, .79, .89).

If a male companion is present, he too may aid in household production, although probably much less than do the women respondents. Across regions there is not much difference in the proportion of households with a companion present (.88, .85, .86). But there are substantial differences for mean years of companion's schooling between the urban and rural areas (6.1, 5.7 and 1.2).

In regard to the impact on average child health, finally, the number of persons over which household commodities have to be spread would seem to be relevant.[19] Mean household size does not vary significantly with urbanization across regions (7.3, 7.2, 7.2). However, more important than the total number of household members is the number of small children, because of the time-intensive demands of pregnancy and infancy. Across regions the average number of live births per year in the past quinquennium (.39, .43, .50), as well as the variance, is inversely associated with urbanization. Of course both the household number and the live births per year may be determined simultaneously with the dependent variables of interest (particularly with mortality if there are replacement births). Therefore, we have estimated our relationships both with and without these variables. Excluding them does not seem to alter significantly the coefficient estimates of the other right-hand-side variables, so for the sake of economy we present below only the relationships in which these variables are included. But the coefficient estimates of these variables still need to be interpreted with care because of possible simultaneity biases.

Nutrition-specific forms of commodity consumption. As we argue in Section 2 above, the use of reduced forms, with no observations on some important variables (particularly related to prices and norms), shows that different households with the same income make different consumption choices even under the maintained hypothesis of identical household utility functions across families. For this reason we include three specific nutrition-related variables. (For a smaller subsample in Table 7 we also include a specific representation of prenatal medical care.)

Our first specific nutrition-related form of consumption is the average standardized caloric intake of the family. We constructed this variable from summing the caloric content of the food which the household consumed in the previous week and normalizing by international standards.[20] Among our three regions those in the smaller urban areas tend to be best off by this measure and those in the rural areas worst, with residents of the central metropolis in between (.62, .75, .49).

Our second specific nutrition-related form of consumption is really a form of capital equipment in household production--refrigeration. Earlier work suggests that the presence of a refrigerator improves nutrient intakes and corresponds to higher given income, education and a number of other characteristics (Wolfe and Behrman, 1980c). The proportion of households with refrigeration once again reflects a dichotomy between the two urban and the rural areas (.28, .28, .02).

Our third specific nutrition-related form of consumption is the length of breastfeeding in months (averaged for all of a woman's children). The urban-rural dichotomy is strong once again (5.3, 5.0, 10.1). This may reflect the greater prevalence of traditional norms regarding breastfeeding and related practices, or the lesser availability of substitutes in the rural as compared to the urban areas. Because of some puzzling results concerning the coefficient estimates for this variable, we estimated some relations for the length of breastfeeding as a function of a number of other variables in our system. The results in Table 2 indicate no significant association with other income, although

Table 2

Regression Estimates of Average Length of Breastfeeding (in months) for Combined Sample

Right-Hand-Side Variables	Estimates (t-statistics)[b]			
Commodity consumption and income				
Other income	-.002	(0.1)	-.004	(0.1)
Woman's predicted earnings	.35	(2.2)	.28	(1.6)
Other factors in household production				
Woman's schooling	-.49	(6.2)	-.40	(3.8)
Woman's age	.13	(4.1)	.17	(4.1)
Informal sector[a]	.45	(1.0)	-.30	(0.6)
Household size	.09	(1.6)	.03	(0.5)
Live births/year	-2.6	(3.6)	-1.5	(1.7)
Nutrition-specific commodities				
Caloric intake	-4.3	(3.8)	-2.3	(1.5)
Refrigeration[a]	- .70	(1.4)	- .61	(1.2)
Public environment				
Sewers[a]	-1.4	(3.2)	-0.2	(0.3)
Parasites[a]	- .01	(0.0)	- .32	(0.7)
Other variables and controls				
Trimesters of medical care			-.16	(0.8)
Expected average schooling			-.15	(2.5)
Constant	7.7	(5.9)	6.2	(3.5)
$\overline{R}^2$	.17		.15	
F	19.5		9.2	
Sample size	1281		745	

[a]See note a in Table 1.

[b]To the right of the point estimates in parentheses are the absolute values of t-statistics. For a two-tailed test at standard significance levels of 5% (10%), a value equal to or greater than 2.0 (1.6) is significant.

there is a significantly positive association with the woman's predicted earnings if the expected average education of her children is not included. Births per year, not surprisingly, have a significantly negative coefficient estimate, since the currently youngest child must be weaned with the coming of the next child. The other significantly nonzero coefficient estimates suggest that longer breastfeeding is a lower socioeconomic class phenomenon, perhaps due to traditional norms or to the opportunity cost of a woman's time: these include a significantly positive estimate for her age, and significantly negative ones for her education, for having sewers, and for the standardized caloric intake and the expected average education of her children.

Public environment (P). We posited in Section 2 that the biological functions of child mortality, health and nutrition status depend directly on certain elements in the environment outside the household. One of the reasons that we subdivide our sample into three regions is that such environments vary so much with the degree of urbanization. We also include three proxies for important within-region differences in these environments.

The first of these is whether or not the home is integrated into a sewerage system.[21] The proportion of households so connected is strongly associated with the degree of urbanization (.75, .30, .03).

The second is the population density. Although the availability of public services and of integrated markets probably increases with population densities up to a point,[22] eventually crowding and congestion are offsetting. For the central metropolis we use data on the population densities within neighborhood sectors. Because of the sparse distribution of population in many of these sectors, particularly after the 1972 earthquake devastated the commercial center of the city, on the average population densities are less in the central metropolis than in other urban areas, although greater than in rural areas (Wolfe, Behrman and Gustafson, 1980; Seoane and Latham, 1971).

The third variable relates in part to the quality of the water supply, although it also reflects the habits of the household and particularly of the woman respondent. As such it pertains to dimensions of household production as well as to the extra-household environment. This variable is whether or not the woman has had parasites. The proportion of households in which the woman has had parasites is lowest in the central metropolis, and slightly higher in the other urban areas than in rural areas (.41, .57, .54).

Other variables and controls. We also are able to include several other variables of interest. One of these is child's sex. The proportions that are male are slightly below half in all three regions (.48, .48, .46). This may represent genetic differences between the sexes, with males presumably tending to be weaker than females. Son preference, however, based on higher expected earnings or status for males, may offset those differences and result in intrafamilial allocations that favor males over females.[23]

A second variable is whether or not the respondent has ever migrated. Migration may reflect the self-selection of individuals with greater ability and motivation for socioeconomic success. It also may result in a wider exposure and a change in reference norms. The lowest proportion of nonmigrants is in the rural areas, with a slightly higher value in the other urban areas than in the central metropolis (.50, .55, .34).[24]

A third variable is child's age. As we note above, we include this variable in the mortality relationships to control for expected systematic underreporting of deaths of very young infants. Based on the literature on breastfeeding and infant health, we expect lower mortality rates for 1-6 months after birth than before or after this period. We include it in the weight and height relations to see if there are systematic associations with age in divergences below standards. For our sample there seems to be some inverse association between mean regional child's age in months and urbanization, although the differences are not statistically significant (Ben-Porath and Welch, 1976; Easterlin, Pollak and Wachter, 1980; and Hu, 1973).

For a smaller subsample for which we have data, we also include three additional variables. The first is reported low birth weight, as indicated by 8% of our total population. This variable relates to a combination of earlier genetic and environmental factors. The second of these is the number of trimesters of medical care during pregnancy, which averages 1.8 for our overall sample. This is possibly an important earlier form of specific commodity consumption. (For our probability of mortality estimates we also are able to include a related variable for whether or not there was medical attention at birth). The third is the expected average years of schooling of the respondent's children, for which we have a mean of 11.1 years among respondents. This can be seen as an alternative form of human capital accumulation to health and nutrition investments, which are generally complements or substitutes for it.[25] As such, it may be endogenous in the model. However, it also may reflect norms and expected household incomes.

Unobserved variables. We remind the reader that there are several variables which are included in the model of Section 2 on which we have no observations or very poor proxies. One important example is market prices, and a second is norms. The absence of these is among the factors that led us to subdivide our sample into regions by degree of urbanization. A third important example is genetic endowments and a myriad of other possible family effects. Of course, the absence of these variables does not cause biases in our estimated coefficients if the unobserved variables are uncorrelated with our observed variables. In some cases, however, this seems a very strong assumption. In particular, schooling quite possibly is correlated with unobserved abilities, motivations and norms.[26]

ESTIMATES

Table 3 contains probit estimates for the probability of reported child mortality. Tables 4, 5 and 6, respectively, give ordinary least squares estimates with the dependent variables representing standardized weight, height and biceps size. In all four of these tables, estimates are presented for the combined sample and for each of the three regions. In general the estimated relationships are significant at standard levels. They also differ significantly among regions in terms of general coefficient estimates and not just of additive shifts (although the additive shift term for the rural areas is significant for biceps circumferences). Therefore the subdivision of the sample is important, although we cannot identify whether this is so because of differential prices, norms, or degrees of unperceived jointness across regions. Table

Table 3

Probit Estimates of Probability of Child Mortality
For Combined Sample and Regions

Variables	Combined Sample[b]	Central Metropolis[b]	Other Urban[b]	Rural[b]
Commodity consumption and income (100's of cordobas per fortnight)				
Other income	-.01 (0.5)	-.02 (0.8)	-.01 (0.4)	.04 (0.3)
Woman's predicted income	.02 (0.3)	-.09 (0.7)	.04 (0.6)	-.01 (0.0)
Other factors in household production				
Woman's schooling (years)	-.09 (3.0)	-.06 (1.0)	-.10 (2.6)	-.05 (0.4)
Age (years)	.00 (0.3)	.00 (0.0)	.00 (0.3)	-.01 (0.3)
Participation in informal sector[a]	-.09 (0.6)	-.12 (0.4)	-.28 (1.3)	-.13 (0.2)
Male companion present[a]	-.12 (0.7)	-.08 (0.2)	-.07 (0.3)	-.52 (0.7)
Schooling (years)	.01 (0.4)	.06 (1.3)	.00 (0.0)	-.01 (0.2)
Household size	-.02 (1.1)	.01 (0.2)	-.05 (1.9)	.00 (0.1)
Births/year in five years	.58 (2.8)	.79 (2.2)	.04 (0.1)	1.0 (1.8)
Nutrition-specific commodities				
Average caloric intake	.46 (1.2)	1.5 (1.5)	-.37 (0.8)	-.46 (0.3)
Refrigeration[a]	.21 (1.4)	.10 (0.3)	.23 (1.1)	1.7 (1.3)
Length of breastfeeding (months)	-.02 (1.5)	-.03 (1.1)	-.00 (0.1)	-.05 (1.6)
Public environment				
Sewers[a]	-.55 (4.0)	-.32 (1.1)	-.48 (2.2)	.03 (0.0)
Population density (people/km^2)	.00 (0.9)	.00 (1.1)	.00 (0.6)	-.00 (0.6)
Parasites[a]	.16 (1.4)	-.08 (0.3)	.30 (1.9)	-.38 (1.0)
Other variables and controls				
Male[a]	.02 (0.2)	-.24 (0.9)	.14 (0.9)	-.24 (0.6)
Never migrated[a]	.15 (1.3)	.35 (1.3)	.05 (0.3)	-.48 (0.8)
Child's age (months)	.11 (2.7)	.26 (2.6)	.07 (1.4)	.15 (1.2)
Low birth weight[a]	.61 (3.9)	.42 (1.1)	.76 (3.5)	.85 (1.6)
Trimesters of medical care	-.05 (1.0)	.11 (1.0)	-.08 (1.2)	.01 (0.0)
Medical attention at birth[a]	-.09 (0.7)	-.30 (1.0)	-.03 (0.2)	.18 (0.3)
Rural[a]	.10 (0.5)			
Constant	-2.0 (4.1)	-4.2 (3.3)	-.70 (1.0)	-.77 (0.5)
2* log likelihood	88.4	32.8	61.1	20.4
Sample size of which number died	1871	888	830	153

[a]See note a in Table 1.

[b]See note b in Table 2.

Table 4

Regression Estimates of Standardized Child Weight
for Combined Sample and Regions

Right-Hand-Side Variables	Combined Sample[b]		Central Metropolis[b]		Other Urban[b]		Rural[b]	
Commodity consumption and income (100's of cordobas per fortnight)								
Other income	.00	(0.3)	.00	(0.0)	-.01	(0.8)	.02	(2.1)
Woman's predicted income	.00	(0.1)	-.04	(0.8)	.07	(1.3)	.02	(0.1)
Other factors in household production								
Woman's schooling (years)	.04	(2.4)	.05	(1.6)	.04	(1.6)	.09	(2.1)
Age (years)	.00	(0.0)	.00	(0.1)	-.01	(0.6)	.00	(0.4)
Participation in informal sector[a]	.27	(3.0)	.43	(2.9)	.38	(2.2)	.08	(0.3)
Male companion present[a]	.02	(0.2)	.06	(0.3)	-.18	(1.1)	.24	(1.1)
Schooling (years)	.01	(1.2)	.03	(1.4)	.01	(0.7)	-.02	(0.5)
Household size	-.03	(2.4)	-.03	(1.6)	-.02	(1.0)	-.04	(1.5)
Births/year in five years	-.34	(2.3)	-.63	(2.3)	-.57	(2.2)	.11	(0.4)
Nutrition-specific commodities								
Average caloric intake	.54	(2.2)	-.34	(0.7)	.91	(2.4)	1.2	(2.1)
Refrigeration[a]	.26	(2.6)	.38	(2.4)	.13	(0.9)	-1.1	(1.6)
Length of breastfeeding (months)	-.01	(1.8)	-.02	(2.1)	-.01	(0.5)	-.00	(0.1)
Public environment								
Sewers[a]	.19	(2.1)	.15	(1.0)	.23	(1.6)	.60	(1.2)
Population density (people/km^2)	-.00	(1.6)	.00	(1.1)	-.0004	(2.0)	-.00	(0.0)
Parasites[a]	.10	(1.4)	.12	(0.9)	.11	(0.9)	.02	(0.1)
Other variables and controls								
Male[a]	-.07	(1.0)	.03	(0.2)	-.06	(0.6)	-.30	(2.1)
Never migrated[a]	-.03	(0.4)	-.02	(0.1)	-.02	(0.2)	.01	(0.1)
Child's age (months)	-.01	(6.4)	-.02	(5.0)	-.01	(3.3)	-.01	(1.4)
Rural[a]	-.04	(0.4)						
Constant	-.38	(1.8)	.09	(0.2)	-.52	(1.0)	-1.4	(2.2)
$\overline{R}^2$	.14		.13		.15		.12	
F	10.2		3.8		4.2		1.7	
Sample size	1281		517		499		265	

[a]See note a in Table 1.

[b]See note b in Table 2.

Table 5

Regression Estimates of Standardized Child Height for Combined Sample and Regions

Right-Hand-Side Variables	Combined Sample[b]		Central Metropolis[b]		Other Urban[b]		Rural[b]	
Commodity consumption and income (100's of cordobas per fortnight)								
Other income	.01	(1.0)	.00	(0.3)	-.01	(1.3)	.03	(3.4)
Woman's predicted income	-.02	(0.5)	-.04	(0.8)	.06	(1.0)	.07	(0.3)
Other factors in household production								
Woman's schooling (years)	.05	(2.7)	.05	(1.9)	.06	(1.9)	.10	(1.9)
Age (years)	.01	(0.7)	.01	(1.3)	.01	(0.7)	.02	(1.3)
Participation in informal sector[a]	.02	(0.2)	.02	(0.2)	.41	(1.9)	.18	(0.5)
Male companion present[a]	.14	(1.1)	-.07	(0.3)	.08	(0.4)	.41	(1.5)
Schooling (years)	.03	(2.3)	.05	(2.2)	.04	(2.0)	-.04	(0.8)
Household size	-.02	(1.9)	-.04	(2.0)	.01	(0.4)	-.05	(1.7)
Births/year in five years	-.72	(4.3)	-.87	(3.4)	-.97	(3.1)	-.26	(0.8)
Nutrition-specific commodities								
Average caloric intake	.71	(2.6)	-.45	(0.9)	.95	(2.1)	2.6	(3.6)
Refrigeration[a]	.15	(1.4)	.32	(2.2)	.03	(0.1)	-.72	(0.9)
Length of breastfeeding (months)	-.02	(2.4)	-.02	(2.2)	-.02	(1.6)	-.01	(1.6)
Public environment								
Sewers[a]	.11	(1.1)	.18	(1.2)	-.04	(0.2)	.61	(1.0)
Population density (people/km^2)	-.000	(1.4)	.003	(1.7)	-.00	(1.2)	.00	(0.1)
Parasites[a]	.14	(1.7)	.15	(1.2)	.05	(0.4)	.25	(1.4)
Other variables and controls								
Male[a]	.03	(0.3)	-.00	(0.0)	.12	(0.9)	-.10	(0.6)
Never migrated[a]	.08	(0.9)	.12	(0.9)	.09	(0.6)	.12	(0.6)
Child's age (months)	-.03	(10.1)	-.03	(7.6)	-.02	(4.7)	-.02	(2.9)
Rural[a]	-.13	(1.0)						
Constant	-.84	(2.6)	-.31	(0.6)	-1.3	(2.1)	-3.2	(4.2)
$\overline{R}^2$	.22		.21		.18		.22	
F	18.1		6.8		5.3		3.6	
Sample size	1281		517		499		265	

[a]See note a in Table 1.

[b]See note b in Table 2.

Table 6

Regression Estimates of Standardized Biceps Circumference for Combined Sample and Regions

Right-Hand-Side Variables	Combined Sample[b]		Central Metropolis[b]		Other Urban[b]		Rural[b]	
Commodity consumption and income (100's of cordobas per fortnight)								
Other income	.00	(0.9)	.00	(0.8)	.00	(0.2)	.001	(1.7)
Woman's predicted income	.00	(1.0)	.00	(0.6)	.00	(1.1)	-.01	(1.5)
Other factors in household production								
Woman's schooling (years)	.003	(2.6)	.002	(1.8)	.003	(1.9)	.01	(2.8)
Age (years)	.00	(0.0)	.00	(0.2)	.00	(0.6)	-.00	(0.7)
Participation in informal sector[a]	.01	(1.5)	.02	(2.1)	.01	(1.3)	-.01	(0.5)
Male companion present[a]	.01	(0.8)	-.00	(0.2)	-.01	(0.5)	.03	(2.1)
Schooling (years)	.00	(0.3)	.00	(0.8)	.00	(0.2)	-.00	(0.9)
Household size	-.001	(1.5)	-.002	(1.8)	-.00	(0.6)	.00	(0.5)
Births/year in five years	-.03	(3.2)	-.05	(2.9)	-.03	(2.3)	-.00	(0.1)
Nutrition-specific commodities								
Average caloric intake	.00	(0.2)	-.04	(1.3)	.02	(0.9)	.06	(1.9)
Refrigeration[a]	.01	(2.4)	.01	(1.2)	.02	(2.2)	-.03	(0.7)
Length of breastfeeding (months)	-.001	(2.6)	-.001	(1.8)	-.001	(1.7)	-.001	(1.9)
Public environment								
Sewers[a]	.01	(2.6)	.01	(1.1)	.01	(1.0)	.01	(0.5)
Population density (people/km^2)	-.00	(2.4)	.00	(1.5)	-.00	(2.6)	-.00	(0.1)
Parasites[a]	.00	(0.1)	.00	(0.1)	-.00	(0.4)	.01	(0.7)
Other variables and controls								
Male[a]	.01	(2.5)	.01	(1.3)	.01	(2.0)	.00	(0.4)
Never migrated[a]	-.00	(0.7)	-.00	(0.2)	-.00	(0.1)	-.02	(1.7)
Child's age (months)	.0004	(2.6)	.002	(0.8)	.00	(1.2)	.001	(3.0)
Rural[a]	-.01	(2.0)						
Constant	.92	(53.7)	.96	(30.1)	.90	(31.1)	.85	(23.4)
$\bar{R}^2$	.12		.09		.13		.14	
F	8.5		2.5		3.5		2.0	
Sample size	1281		517		499		265	

[a]See note a in Table 1.

[b]See note b in Table 2.

7 gives alternative estimates for the standardized weight, height and biceps dependent variables for the subsample (combined across regions) for which the three additional variables discussed at the end of Section 3 are available. We organize our discussion of these estimates with reference to the estimated effects of the right-hand-side variables in the same order as in the previous section.

Commodity consumption (Z) and income. We find very little evidence of a substantial impact of either other income or the woman's predicted earnings. The only significant coefficient estimates are positive ones in the weight and height relationships for other income in the rural areas at the 10% level, which is also significant in the relationship with biceps circumference, as is the coefficient estimate in the combined sample of the woman's predicted earnings in Table 7. That the rural areas are relatively poor suggests that there may be an Engel curve phenomenon with more response at low-income levels. Even the magnitudes of these significant estimates, however, are not very large. Therefore we conclude that our results are not consistent with there being an important generalized income effect (whether nominal or more "full") on child health in this developing country, a conclusion which is similar to that attained for the United States (Chernichovsky and Coate, 1979; Edwards and Grossman, 1977).

Other factors in household production. We find evidence of a fairly widespread impact on child health of the woman's education and participation in the informal sector (although not of her age). At the standard 5% level of significance, the woman's education is inversely associated with the probability of child mortality in other urban areas and in the combined sample, positively associated with weight and biceps

Table 7

Regression Estimates of Standardized Child Weight, Height, and Biceps Circumference for Smaller Combined Sample

Right-Hand-Side Variables	Standardized Weight[b]		Standardized Height[b]		Standardized Biceps Circumference[b]	
Commodity consumption and income (100's of cordobas per fortnight)						
Other income	-.00	(0.2)	-.00	(0.4)	.00	(0.3)
Woman's predicted income	.02	(0.4)	.00	(0.0)	.01	(1.9)
Other factors in household production						
Woman's schooling (years)	.02	(0.9)	.04	(1.6)	.00	(1.0)
Age (years)	-.01	(1.1)	-.01	(1.1)	-.00	(0.6)
Participation in informal sector[a]	.29	(2.4)	.15	(1.2)	.02	(2.3)
Male companion present[a]	.08	(0.5)	.20	(1.2)	.00	(0.4)
Schooling (years)	.00	(0.3)	.02	(1.1)	-.00	(0.5)
Household size	-.04	(2.2)	-.01	(0.8)	-.002	(2.1)
Births/year in five years	-.55	(2.7)	-.93	(4.3)	-.04	(2.9)
Nutrition-specific commodities						
Average caloric intake	.29	(0.8)	.03	(0.1)	-.02	(1.2)
Refrigeration[a]	.35	(2.8)	.25	(1.8)	.02	(2.1)
Length of breastfeeding (months)	-.02	(2.1)	-.02	(2.3)	-.002	(3.3)
Public environment						
Sewers[a]	.13	(1.2)	.03	(0.2)	.01	(2.0)
Population density (people/km^2)	-.00	(0.8)	-.00	(0.4)	-.00	(1.1)
Parasites[a]	.09	(0.9)	.13	(1.1)	-.00	(0.2)
Other variables and controls						
Male[a]	-.05	(0.5)	.05	(0.4)	.01	(1.6)
Never migrated[a]	-.05	(0.5)	.05	(0.4)	-.01	(1.0)
Child's age (months)	-.02	(4.9)	-.03	(7.3)	.0004	(1.9)
Low birth weight[a]	-.53	(2.9)	-.53	(2.7)	-.04	(3.2)
Trimesters of medical care	-.00	(0.0)	-.04	(0.8)	.00	(0.1)
Expected average schooling	.02	(1.6)	.02	(1.6)	.00	(0.1)
Rural[a]	.13	(0.5)				
Constant	.25	(0.6)	-.01	(0.0)	.97	(38.0)
$\overline{R}^2$	.13		.16		.12	
F	4.7		6.4		4.5	
Sample size	745		745		745	

[a]See note a in Table 1.

[b]See note b in Table 2.

measures in the rural area and with height in the combined sample. At the 10% level it is positively associated with height in all three regions and with the biceps measure in the two urban areas. We interpret these results to reflect the efficiency of the woman in household production, with the above mentioned caveat about schooling representing tastes and genetics. If so, then our estimates lead to a conclusion similar to that of Edwards and Grossman (1977) for the United States, regarding the relatively greater importance of a woman's education in comparison to income in determining her children's health.

The participation of working women in the informal sector has significant positive coefficient estimates in the weight relationships for both urban areas and the combined sample, in the health relationship for other urban areas (at the 10% level), and in the biceps relationship for the central metropolis (and in the combined sample of Table 7). As we anticipate in the previous section, we interpret these estimates to reflect the fact that women who work in the informal sector often are able to combine child care with work and thus to devote more total time to household production than working women in the formal and domestic sectors.

We find much less evidence of an impact of a male companion than of the woman's characteristics. The only significant coefficient estimates are positive ones for the presence of a male companion in the biceps relationship for rural areas and for the male companion's schooling for the height relationship in both urban areas and in the combined sample. That the coefficient estimates for male's schooling are significant only for height may be due to genetic endowments, which would seem to be more important for permanent than for transitory health and nutrition status.

However, the same results might hold if the male's education were a better measure of permanent income than other income.

The more frequent significance of the estimates for women's than for men's schooling, together with the predominance of the former in household production, is consistent with an efficiency interpretation for women's schooling rather than a genetic one. However, it also is consistent with an interpretation that schooling affects tastes, and that women's tastes predominate in child-health-related decisions. Thus, although we favor the efficiency interpretation for women, we remain uncertain about what schooling is representing in our estimates.

Finally, we find evidence of a widespread inverse impact of household size, and especially of other recent births, on child health and nutrition status. Household size has significantly negative coefficient estimates for the combined sample for weight, for height in the central metropolis (and at the 10% level in the combined sample), and for biceps circumference in the smaller combined sample of Table 7. The number of live births per year in the past quinquennium significantly increases the probability of child mortality in the central metropolis and in the combined sample (as well as in the rural areas at the 10% level) and reduces weight, height and biceps circumference in both urban areas and in the combined sample. Subject to the above caveat about simultaneity (particularly regarding replacement births in relation to mortality), these results suggest that greater numbers of children reduce average child health and nutrition levels both transitorily and permanently by causing a given level of household commodities to be spread more thinly.

Nutrition-specific forms of commodity consumption. We find fairly general evidence of the impact of nutrition-specific forms of commodity consumption on child health and nutrition status, which contrasts with the limited relevance of the generalized income (expenditure) variables. As we discuss above, this pattern suggests that the composition of given aggregate levels of household commodity consumption varies across households because of some combination of different prices, norms and/or utility functions.

The average household standardized caloric intake has significantly positive coefficient estimates for weight and height for other urban areas, other rural areas, and for the combined sample (and at the 10% level for biceps circumference in rural areas). Apparently in both the short and the long run, "you are what you eat."

The lack of significance in the central metropolis, however, is somewhat surprising. In this case, however, the quality of nutrient inputs may be captured better by refrigeration, which has significant positive coefficient estimates for weight and height in the central metropolis (as well as for weight and biceps circumference in the combined sample and for biceps circumference in other urban areas).

The average length of breastfeeding has a significantly negative coefficient estimate at the 10% level for the probability of child mortality in rural areas. However, the other significant coefficient estimates for this variable are somewhat puzzling. They are negative for weight in the central metropolis (and at the 10% level in the combined sample), for height in the central metropolis and in the combined sample (and at the 10% level in other urban areas), for biceps circumference in the combined sample (and at the 10% level in both urban regions), and for all three estimates for the smaller combined sample of Table 7.

One direct interpretation is that prolonged breastfeeding leads to nutritional deprivation in older infants, despite the advantages of initial breastfeeding in transferring immunities, providing a well-balanced diet and avoiding problems due to contaminated water. In such a case, one might expect that the effect of breastfeeding would be quadratic--but adding the square of breastfeeding to the relationships does not eliminate the estimated negative linear effect.

Alternatively, prolonged breastfeeding may be correlated with a low level of household income and overall inputs into the child health and nutrition functions because it limits women's working hours and reduces the probability of their participation in the high-earnings formal sector, particularly in the central metropolis. However, it is difficult to differentiate this possibility from the likelihood that prolonged breastfeeding simply serves as a proxy for low socioeconomic class conditions and norms, as the estimates in Table 2 above might suggest.

Public environment (P). Access to sewers significantly lowers the probability of child mortality in other urban areas and in the combined sample, and increases weight and biceps circumference in the combined sample (and weight at the 10% level in other towns). Population density is significantly negatively associated with biceps circumference in other urban areas and in the combined sample (and at the 10% level with weight in the combined sample, but also positively with height in the central metropolis). Parasites have no significant associations at the 5% level, but at the 10% level have positive ones with child mortality in other urban areas and (perhaps puzzlingly) with height in the combined sample. These estimates are mixed, but suggest that the extra-family environment, particularly regarding sewers, may be important in determining child health and nutrition.

Other variables and controls. We find that males have significantly less weight relative to the age-sex specific international standards in rural areas. This suggests either that males are favored less or are inherently more vulnerable to transitory health and nutrition problems in these rural areas than are males in the U.S. reference population. We also find a significantly positive association with biceps circumference for other urban areas and the overall sample, but we expect that this merely reflects sexual genetic differences that are not controlled for in the normalization.

We obtain no significantly nonzero coefficient estimates for never migrated at the 5% level. At the 10% level this variable has a negative coefficient estimate in the relationship for biceps circumference in rural areas. This result quite weakly suggests that either women who have lived all of their lives in the same rural areas have narrower perspectives (and less knowledge or more traditional tastes) than urban women, to the possible detriment of their children's health and nutrition status.

A child's age has a significantly positive estimated impact on the probability of child mortality in the central metropolis and in the combined sample. As we note above, we interpret this to reflect systematic measurement error in the reporting of deaths of young infants.[27] Child's age also has significantly negative coefficient estimates for weight and height in all of the regions (except for rural areas for the former) and in the combined samples. These estimates are quite robust. They suggest that children in our sample fall progressively further below international standards for transitory and permanent health and nutrition status as they age. Finally, child's age has significantly positive coefficient estimates for biceps circumference for rural areas and for the combined sample. Apparently this reflects better muscular development, ceteris paribus, in the rural than in the urban environments (which carries over to the overall sample because of the somewhat older ages of the rural children).

Low birth weight significantly increases the probability of child mortality in other urban areas and in the combined sample (and at the 10% level in rural areas). It also has significantly negative effects on our other three measures of health and nutrition status in the smaller combined sample of Table 7. Apparently it has considerable correlation over time with infant and child health status, although we cannot identify whether the cause of the initial low weight was genetic or environmental.

In contrast we find no evidence of a significant impact of prenatal or partum medical care (trimesters of medical care or medical care at birth).

Finally, we obtain positive coefficient estimates which are significantly zero only at the 10% level for average expected education of children in the smaller combined sample for height and weight. The association between various human capital investments is not obviously very strong, particularly in light of the fact that simultaneity probably causes an upward bias, if anything.

CONCLUDING REMARKS

As we discussed in the introduction, knowledge of the determinants of child health and nutrition status is important to understand and to alter both current and future socioeconomic welfare in the developing countries. On the basis of the theoretical framework sketched in Section 2, we have obtained empirical estimates of the determinants of four indexes of child mortality, health and nutrition status in a developing country. A number of important conclusions come out of this analysis.

First, it is important to distinguish among regions identified by the degree of urbanization because the estimates differ significantly among them, particularly between the urban and the rural areas. For example, men's education has significant effects only in the former and other income only in the latter. Our theoretical model suggests that such differences may originate in our inability to control for different relative prices, different norms for preferences and different degrees of unperceived jointness across regions.

Second, our estimates uncover important determinants of current health and nutritional status (i.e., weight) and of long-run or permanent health and nutrition status (height and biceps circumference). Some of the determinants are fairly similar (e.g., nutrition-specific commodities and competition from siblings), but others differ. For example, the additional time for child care which women who work in the informal sector have tends to improve current, but not permanent, child health in urban areas. On the other hand, the male's schooling is associated significantly with permanent, but not current, health--perhaps it represents basic genetic endowments (if he is the father).

Third, income or generalized purchasing power is not a major determinant of child mortality, health and nutrition status. Only for the relatively low-income rural areas, in fact, does it even have significant coefficients at standard levels, and in that case not of particularly large magnitudes. Increasing income levels in the general process of economic development will not quickly improve child health and nutrition status.

Fourth, parental schooling, particularly that of the mother, does have a widespread positive association with child health and nutrition status. With a caveat about identifying efficiency from genetic or tastes effects, we believe that women's schooling represents an important mechanism for improving child health and nutrition status through increasing efficiency in household production. If so, this represents yet another return to women's education in addition to the significant ones we have found elsewhere in regard to fertility and household nutritional demands, as well as representing quite high returns in terms of productivity and earnings (Behrman and Wolfe, 1979, 1980e and 1980h; Behrman, Wolfe and Blau, 1980; Behrman, Wolfe and Tunali, 1980; and Wolfe and Behrman, 1980c). But for such schooling the investment period is quite long. Adult education programs directed towards health and nutrition practices may be more efficient, although we do not have data to test this possibility.

Fifth, again with a qualification about simultaneity, family size and the number of young siblings in particular are inversely associated with child health and nutrition. Thus there does appear to be a quantity-quality trade-off with possible implications for fertility.

Sixth, although generalized income does not have much of an effect, some specific commodities do. In particular the average household caloric intake and the presence of refrigeration are quite important. On the theoretical level the relative importance of specific versus general purchases suggests that there are within-region variations in relative prices and norms, etc., so that specific purchases are not tied to general income in a simple Engel-curve manner. On a practical level, this pattern suggests that there may be a high payoff, in terms of current child health and future adult productivities, to specific programs which improve the nutrition of small children by subsidizing the necessary inputs (see MacDonald et al., 1981, for a similar pattern for the U.S.). However, our estimates do not support the importance of all plausible specific interventions. For example, we find no evidence of a substantial effect for formal medical care.

Seventh, our results suggest that there may be a payoff in terms of better child health and nutrition to some public sector investments, particularly in sewer systems. Better water systems also may have payoffs, but we have not been able to explore this possibility very satisfactorily.

Eighth, we do not find support, and if anything find counterevidence, for the frequent hypotheses that longer breastfeeding has a payoff in terms of better child health and nutrition and that male children are favored in intrafamilial allocation.

These insights, if supported by other studies, should provide a better basis for prediction and policy analysis regarding child health and nutrition status in developing countries--and thus for improving current and long-run welfare.

NOTES

[1]In Wolfe and Behrman, 1980a, we consider the determinants of adult health and nutrition status in the same developing country for which the present study is undertaken. Unfortunately, however, our data set does not permit the exploration of a direct link between the child and adult health of an individual. See Anthony, 1979; Blau, 1977 and 1980; Selowsky, 1976; and Selowsky and Taylor, 1973, and the references therein, regarding evidence of the link between child and adult health and nutrition status. See Behrman and Wolfe, 1979, and 1980c-i; Behrman, Wolfe and Blau, 1980; Behrman, Wolfe and Tunali, 1980; Blau, 1977 and 1980; Tunali, Behrman and Wolfe, 1980; Wolfe and Behrman, 1980c; and Wolfe, Behrman and Blau, 1980, regarding the impact of adult health and nutrition status on adult productivities, earnings, labor force participation and fertility.

[2]Edwards and Grossman (1977) find a significant association between health and intellectual development for children in the United States. We consider the investment in children's education in a developing country elsewhere (Behrman and Wolfe, 1980a and c; Wolfe and Behrman, 1980b). In Behrman and Wolfe, 1980h; Behrman, Wolfe and Blau, 1980; Behrman, Wolfe and Tunali, 1980; and Tunali, Behrman and Wolfe, 1980, we investigate the impact of schooling on adult productivities and earnings.

[3]Under the assumption that fertility is partially under control of the parents, for example, replacement births would be lowered. See Behrman and Wolfe, 1979, and Schultz, 1976.

[4]This survey was collected as part of an extensive study on the role of women in developing countries. As well as works already cited, see

also Behrman and Wolfe, 1980b and j; Wolfe, 1977; Wolfe and Behrman, 1980a; Wolfe, Behrman, Belli and Gustafson, 1979a and b; Wolfe, Behrman and Flesher, 1979; Wolfe, Behrman and Gustafson, 1980; and Ybarra Rojas, 1978, for studies completed to date or currently in progress.

[5]Warren Sanderson uses these labels in his recent review of the 1980 Easterlin, Pollak, and Wachter paper on fertility determinants, and provides a number of earlier references to Pennsylvania studies. The standard references to the seminal Chicago-Columbia school studies include Becker, 1960; Becker and Lewis, 1973; and Becker and Tomes, 1976. Of course the distinctions are not perfectly sharp. The Pennsylvania school incorporates the Chicago-Columbia insights regarding human capital, time allocation and household production, at least on a general level. Michael and Willis (1979), who generally would be classified in the Chicago-Columbia school, incorporate biological factors within a demographic "renewal model" of contraceptive use. Becker and Tomes (1976, 1979), of the Chicago-Columbia school, discuss intrafamilial allocations and intergenerational decisions using a model that is similar in many respects to one developed by Behrman, Pollak and Taubman (1980) of the Pennsylvania school. Nevertheless, the distinction is useful because of certain ongoing differences concerning the endogeneity of preferences, the importance of biological factors, the usefulness of "full" or "social" income measures and shadow prices, etc. Behrman and Taubman (forthcoming, 1981) review many of the issues.

[6]We follow the well-established practice of ignoring the difficult question of how such a function is defined given differential preferences of family members. In one dimension this procedure is more satisfactory for our empirical work than for many similar applications. Since we

focus on the status of children under 5 years of age we can ignore more safely than can many others questions of how children's preferences enter into the household utility function.

[7]For consideration of allocation within families, see Becker and Tomes, 1976 and 1979; Behrman, Pollak and Taubman, 1980; Tomes, 1976; and Behrman and Wolfe, 1980a.

[8]We ignore bequests and in-kind transfers. See the first three references cited in Note 7 for a discussion of such alternatives.

[9]We also could incorporate average child quality instead of expected average child earnings and measures of current average child welfare, but we find the more specific representation of child characteristics more satisfactory.

[10]We assume that the (market) weights for aggregating such skills are given.

[11]Under the assumption that the conditions exist for a maximization.

[12]After we finished this study we became aware of the very interesting Rosenzweig and Schultz study (1980) which assumes specific functions for the parental utility and child health functions (i.e., Cobb-Douglas), eliminates by assumption most of the other complications noted in this section, assumes complete knowledge, and derives explicit demand functions for child health inputs in terms of the original structural parameters and the exogenous variables. In their empirical applications to U.S. data, however, they conclude that the necessary assumptions are too restrictive to be realistic, so they emphasize the results from more general but approximate demand relations which do not permit identification of all of the structural parameters.

[13]We always give statistics for our three regions in decreasing order of urbanization, unless otherwise noted. To keep the presentation concise, however, we do not always repeat the regional identifications.

[14]Instead of standardizing for age-sex group, it would be possible as an alternative to include some function of age and sex as an additional right-hand-side variable in the relationship. We do not estimate such an alternative because we believe that age and sex affect weight and height more generally than an additive function could capture. The considerations are analogous on the question of alternative controls for age and length of exposure for fertility variables to those that we discuss in Behrman and Wolfe, 1980e.

[15]We qualify our statement about genetic controls with the adverb "partially" because we do not believe that the distributions of weights and heights for the base sample for these norms (i.e., children in Yellow Springs, Ohio) are independent of environmental factors. They probably are, however, free of subnourishment. See Berg, 1973, and Zerfas et al., 1975, for further discussion of such indexes.

[16]In Behrman, Wolfe and Blau, 1980; and Wolfe, Behrman and Blau, 1980, we examine the role of demographic and human capital variables in the determination of the regional and combined household distributions of income and its major components.

[17]We present related evidence about the incompatibility of child care and high-earnings, formal-sector jobs in Behrman and Wolfe, 1980h; Behrman, Wolfe, and Blau, 1980; Behrman, Wolfe and Tunali, 1980; and Tunali, Behrman and Wolfe, 1980.

[18]In Behrman and Wolfe, 1980h, and in Behrman, Wolfe and Tunali, 1980, we present statistical evidence that the presence of small children

and the absence of home child care selects working women away from formal and domestic employment and into the informal sector.

[19]At least as long as such commodities are not entirely public goods within the family, which would seem quite unlikely.

[20]We also constructed similar measures of protein and vitamin A and iron intakes, since these also are in relatively limited supply. However, the best single measure of nutrient deficiencies for our sample is the caloric one, and multicollinearity precludes the inclusion of other measures simultaneously. For further discussion for the central metropolis, see Wolfe and Behrman, 1980c.

[21]Antonovsky (1979), Dyson (1978) and Puffer and Serrano (1973) report inverse associations between the quality of housing (particularly regarding water and sanitation) and infant and child mortality in developing countries.

[22]In Wolfe and Behrman, 1980c, we find some evidence consistent with this pattern for food markets in the central metropolis.

[23]In Behrman, Wolfe and Blau, 1980, and Behrman, Wolfe and Tunali, 1980, we find that expected average earnings are higher for males than for females, even though the marginal returns to schooling are greater for the latter.

[24]We explore the micro-determinants of migration in terms of person-specific earnings options, marriage options, and differential public services in Behrman and Wolfe, 1980g.

[25]If the expected earnings function is log linear, and human capital investments affect parental utility only though these expected earnings, intrafamilial relative allocations of investments in schooling are proportional to those in health and nutrition.

[26]For evidence that estimates of the returns to schooling in the United States may be biased upwards due to the failure to control for ability and motivation, see Behrman, Hrubec, Taubman and Wales, 1980. In Behrman and Wolfe, 1980c, we undertake a similar investigation, using the same sample that we use in this study.

[27]Alternatively, this result may reflect a pattern in which mortality is relatively low during the 1-5 month range, so that the impact of age is nonlinear.

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