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

Barbara L. Wolfe
Department of Economics and
Preventive Medicine,
Institute for Research on Poverty,
University of Wisconsin - Madison

and

Jere R. Behrman
Department of Economics and
Population Studies Center
University of Pennsylvania

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1. 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 in themselves of current socioeconomic welfare, and there is evidence that these levels often are low in developing countries. Second, child health and nutrition status significantly condition subsequent adult intelligence and health and nutrition status, which have direct impact on adult productivities and earnings and the quality of life.[1] Third, child health, mortality and nutrition status may be related to other investments in children, such as in education, and thereby have indirect long-run impact on adult productivities and earnings.[2] Fourth, child health and nutrition status may be important intervening variables through which intergenerational socioeconomic mobility is limited. For example, if parental education or income directly (or indirectly, say, through the number of siblings) affects child health and nutrition, and the child health and nutrition affect the adult options of that individual directly or indirectly, poverty may be transmitted through such a channel. Fifth, among family characteristics that affect child health status in the United States, family income is relatively unimportant, but parental education is much more so (32, 38). It is important to ask whether this and other similar results hold for developing countries in which incomes are much lower. The answer may affect substantially the choice of high payoff policy interventions. Sixth, according to Merrick (47), child mortality is higher at least in the Latin American part of the developing world than at a stage of comparable life expectancies in the more developed countries because of the greater current effectiveness of health interventions in reducing adult mortality than in reducing child mortality, with a feedback

on fertility and overall child quality.[3] Better knowledge of the determinants of child mortality may shed some light on this possibility. Seventh, there is some 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 (34). In order to evaluate the returns to improved pre- and peri-natal care, some quantification of this link is useful. Eight, many studies in the human capital tradition for developed countries and some for developing countries (eg., 29) suggest a child quality-quantity trade-off. If this trade-off exists, improved child quality in terms of health may be associated with 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. Therefore in this paper we present the results of efforts to investigate this topic in-so-far as is possible with data which we have collected in a cross section multipurpose survey of women of childbearing age in the Central American developing country of Nicaragua.[4] In Section 2 we present our a priori rationale for specification of multivariate relations to determine child health and nutrition status. In Section 3 we introduce our data set and define the relevant variables. In Section 4 we present and discuss our multivariate estimates. In Section 5 we give our concluding remarks.

2. Model Specification

We build upon economic models of household behavior developed in the past two decades, with "Chicago-Columbia school" emphasis on the role of human capital, household production, and the allocation of time and "Pennsylvania school" emphasis on intergenerational considerations, biological factors, imperfect knowledge, and the endogeniety 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) and health (H) and nutrition (N) status, and practices like breastfeeding, contraception, and frequency of coition (B), all conditional on norms concerning commodity consumption (Z*), number of children (C*), and practices like breastfeeding and frequency of coition (B*):

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

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 of consideration of sexual differences in our empirical work below.[7]

We include expected average earnings of children because of a posited parental concern about the children's adult prospects in addition to a concern about children's current welfare.[8] The former may relate to pure concern about intergenerational family welfare or to concern about potential transfers from the chilren to the parents in the parents old age, which probably 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 below by assuming that parents are concerned with average child characteristics only in so far as they affect expected average child earnings as adults as in some other studies (7, 10), 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

the 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 infantcide would be much more widely practiced then it apparently is as a method of disposing of excess children.

We include practices like breastfeeding, contraception, and frequency of coition as a reminder that such practices do have disutility costs and benefits. If not, for example, abstinence would be the dominant method of contraception and there never would be excess children in a world of certainty (36). For purposes of the present study, breastfeeding is the most important of these practices which is observable.

We include various norms to emphasize that preferences are conditional on such norms and these 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 changes 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 the reference norms differ across communities in developing countries depending on the 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) can not 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 breastfeeding), etc. cannot exceed total time available for each individual. However

in developing countries the distinction between market and nonmarket activities often is 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 (20, 24, 25).

(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 simulatenously, 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 are those of men (as Leibowitz (44) claims is the case for the United States).

(5) An average child 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 child birth 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 genetics and earlier human capital investments in the parents) to relate to parental health and fecundity status and on the frequency of coition, contraceptive choice, and choices regarding such practices as breastfeeding (B).

(7) Biological child mortality (M), health (Y) and nutrition (N) status functions that depend upon average child genetic endowments (G), commodity consumption (Z) and the public environment (P), and parental practices regarding such activities as breastfeeding (B). In the production of commodities that enter into these functions, parental education may

be particularly important under the plausible assumptions that more educated parents tend to be more knowledgeable about preventive and curative health and nutrition measures, more capable of following medical and nutritional advice or instructions, less fatalistic about illness and therefore prone to seek medical help for a sick child, and more child oriented due to increased roles of mothers in intrafamilial decisions (eg., see Behm, 8, Caldwell, 3 and Cochrane, 33).

(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 equal the number born 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 (eg., Z, C, B, E). If parents only partially perceive the constraints due to what Easterlin, Pollak and Wachter (36) term "unperceived jointness," they can maximize utility with respect to the constraints that they perceive, but in the process they unknowingly determine outcomes for all of the 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 of the constraints and derive explicit solutions for the optimal levels of child mortality, health and nutrition status with 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 indeterminant 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 partly be serving 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.

3. 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 1871 cases we have child mortality data. For 1281 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 (ie., 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.

3.1 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 given the positive association between urbanization and income, schooling, health care facilities, and good water and sanitation. But the levels are low relative to other estimates. Probably they are underestimates becuase they are based on reported recall data. We expect in particular that deaths of very small infants may be underreported so we control for the 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.

Standardized 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 (50), and divided the difference by the sex-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 that is 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 (30, 37, 38, 40, 74).

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 international standards, 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 (37, 38, 73). It assumes that potential height is the same across ethnic groups (40).

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 measure (.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 bicep circumference: This variable is standardized relative to the mean international value for a child of the identical age (59).

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 bicep 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 bicep 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 bicep 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 bicep measures supposedly represent long-run nutrition status, while the standardized weight measure supposedly represents short-run nutrition status. But note that the standardized bicep 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 a half of the variation in the other. Therefore either measurement error is important or they are refering to different dimensions of long-run nutritional status.

3.2 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 and 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 the woman's earnings ("other income") as an exogenous variable which represents 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 (23, 69, 70). The assumption of exogeniety 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 (23, 69, 70). 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 exogeniety 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 for other income across regions have means that are about twice as high for the two urban areas than as for the rural areas, but 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 both in regard to 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 <u>woman's predicted earnings,</u> as estimated from earnings functions with a control for selectivity in labor force participation (20, 24, 25, 61). This gives us a much better measure than would actual earnings of the relative contribution across 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. It also lessens the possibility of

confounding earnings with breastfeeding in the multivariate context since actual earnings may be inversely associated with breastfeeding since the latter normally is not practiced while working at high earnings 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 (20). 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 again, however, that this variable may be representing in part differential norms or genetic endowments. Across the regions, once again, 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 also 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 (.85, .85, .86). But there are substantial differences, once again, 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] The mean household sizes do not significantly vary 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 quinquenium (as well as the variance) is inversely associated with urbanization (.39, .43, .50). Of course both of these variables may be simultaneously determined with the dependent variables of interest (particularly with mortality if there are replacement births). Therefore we have estimated our relations below 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 relations with these variables included. But the coefficient estimates therein of these variables still need to be interpreted with care because of possible simultaniety biases.

Nutrition-specific forms of commodity consumption: As we argue in Section 2 above, the use of reduced forms and no observations on some important variables (particularly related to prices and norms) means 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 nutrition related specific 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 other 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 nutrition related specific form of consumption really is a form of capital equipment in household production -- refrigeration. Earlier work suggests that the presence of refrigerator improves nutrient intakes, given income, education, and a number of other characteristics (66). The proportion of households with refrigeration once again reflects a dichotomy between the two urban and the rural areas (.28, .28, .02).

Our third nutrition related specific form of consumption is the (average for all of her children) length of breastfeeding in months. The urban-rural dichotomy is strong yet once again (5.3, 5.0, 10.1). This may reflect the greater prevalence of more traditional norms regarding breastfeeding and related practices or the lesser availability of substitutes in the rural than in 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 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, has a significantly negative coefficient estimate in this case since the currently youngest child must be weaned with the coming of the next child. The other significantly nonzero coefficient estimates suggest that the length of breastfeeding is a lower socioeconomic class phenomenon, perhaps because of more traditional norms or because of lower opportunity costs of the woman's time: a significantly positive estimate for her age and significantly negative ones for her education, having sewers, the standardized caloric intake, and the expected average education of her children.

Public environment (P): We posit in Section 2 that the biological child mortality, health and nutrition status functions depend directly on certain elements of the extra-household environment. 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. 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,[21] eventually crowding and conjestion 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 commerical 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 (72, 172, 59).

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 the sex of the child. The proportions that are male are slightly below half in all three regions (.48, .48, .46). This may represent genetic differences between the sexes, presumedly with males tending to be weaker than females. Offsetting male preferences, however, based on higher expected earnings[22] or status, may result in intrafamilial allocations that favor males over females.

A second is whether or not the respondent migrated ("never migrated"). Migration may reflect self selection of individuals with greater abilities and motivations for socioeconomic success. It also may result in a wider exposure and a change in reference norms. Perhaps surprising is the fact that the lowest proportion of non migrants is in the rural areas, with a slightly higher value in the other urban areas than in the central metropolis (.50, .55, .34).[23]

A third is the child's age. As we note above we include this variable in the mortality relations 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 divergencies below the international 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 (26, 36, 42).

For a smaller subsample for which we have the 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 a possibly 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 schooling of the respondent's children, for which we have a mean of 11.1 years among respondents. This partly relates to a form of human capital accumulation alternative to health and nutrition investments, which generally may be a complement or a substitute.[24] As such it may be endogenous in the model. However it also may reflect norms and expected household incomes.

Nonobserved 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 the norms, the absence of which are two of the several factors that lead us to subdivide our sample into regions by the degree of urbanization. A third important example is genetic endowments and a myraid 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. However in some cases this seems a very strong assumption. In particular, schooling quite possibly is correlated with unobserved abilities and motivation and norms.[25]

4. 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 standardized weight, height and bicep dependent variables. In all four of these tables estimates are presented for the combined sample and for each of the three regions. In general the estimated relations are significant at standard levels. They also differ significantly among regions in terms of general coefficient estimates and not just additive shifts (although the additive shift term for the rural areas is significant for bicep circumferences). Therefore the subdivision of the sample is important, although we can not identify whether this is so because of differential prices, norms, or degrees of unperceived jointness across regions. Table 7 gives alternative estimates for the standardized weight, height and bicep 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 significaht coefficient estimates are positive ones in the weight and height relations for other income in the rural areas (at the 10% level that in the biceps relation also is significant, as is the coefficient estimate of the woman's predicted earnings in the combined sample bicep relation of 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 (whether nominal or more "full") effect on child health in this developing country, a conclusion which is similar to that attained for the United States (32, 37).

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, and positively associated with weight and bicep 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 bicep 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 (37) for the United States regarding the relatively great importance of women's education in comparison to income in determining child health.

The participation of working women in the informal sector has significant positive coefficient estimates in the weight relations for both urban areas and the combined sample, in the health relation for other urban areas (at the 10% level), and in the bicep relation 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 that working women who work in the informal sector often are able to combined child care with their work and thus 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 bicep relation

for rural areas and for the male companion's schooling for the height relation 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 is a better measure of permanent income than is 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 schooling affecting tastes and women's tastes predominating in child health related decisions. Thus, although we favor the efficiency interpretation for women, we remain with some ambiguity about what schooling is representing in our estimates.

Finally we find evidence of a widespread inverse impact of household size, especially 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 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 bicep circumference in both urban areas and in the combined sample. Subject to the above caveat about simultaniety (particularly regarding replacement births in the mortality relation), 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 bicep circumference in rural areas). Apparently in the short and long runs, "you are what you eat."

The lack of significance in the central metropolis, however, is somewhat surprising. However in this case 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 bicep circumference in the combined sample and for bicep 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 bicep 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 long breastfeeding leads to nutritional deprivation in older infants despite the possible advantages of initial breastfeeding in terms of the transference of immunities and a well-balanced diet and the avoidance of 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 relations does not eliminate the estimated negative linear effect.

Alternatively, breastfeeding may reduce household income and overall inputs into the child health and nutrition functions by lowering women's working hours and reducing the probability of their participation in the high-earnings formal sector, particularly in the central metropolis. However it is difficult to identify this possibility from the one that long breast-feeding simply is serving 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 bicep circumference in the combined sample (and weight at the 10% level in other towns). Population density is significantly negatively associated with bicep 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 puzzling) with height in the combined sample. These estimates are mixed, but suggest that the extra-family environment, particularly regarding sewage, might 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 in the international reference population. We also find a significantly positive association with bicep 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% this variable has a negative coefficient estimate in the relation for bicep circumference in rural areas. This result (quite) weakly suggests that women who have lived all of their life in the same rural areas have narrower perspectives (and less knowledge or more traditional tastes) to the detriment of their children's health and nutrition status.

The 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.[26] 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 bicep 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 there is considerable correlation over time in 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 (trimesters of medical care) or partum (medical care at birth) medical care. Our estimates suggest that this form of specific commodity consumption does not affect the subsequent health and nutrition status of children.

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.

5. Concluding Remarks

As we discuss 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 bases of the theoretical framework which is sketeched in Section 2 we have obtained empirical estimates of the determinants of four indices of child mortality and 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 only has significant effects 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 (ie., weight) and of long-run or permanent health and nutrition status (height and bicep circumference). Some of the determinants are fairly similar (eg., nutrition-specific commodities and competition from siblings), but others differ. For example the additional time for child care which working 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 because it is representing basic genetic endowments.

Third, income or generalized purchasing power is <u>not</u> 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 elsewhere have found in regard to fertility and household nutritional demands, as well as quite high returns in terms of productivity and earnings (12, 17, 20, 23,

24, 25, 66). But for such schooling the gestation 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 nutrition of small children by subsidizing the necessary inputs. However our estimates do not support the importance of all plausible specific interventions. For example we do not find 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.

Such 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.

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	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
Commodity consumption and income:						
other income (100's of cordobas per fortnight)	7.1	7.0	6.8	8.5	3.5	9.2
woman's predicted income (same units)	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 bicep circumference	.96	.09	.95	.08	.91	.07

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

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	-.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)
$\bar{R}^2$	.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 or greater than 2.0 (1.6) is significant.

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:				
other income (100's of cordobas per forthight)	-.01(0.5)	-.02(0.8)	-.01(0.4)	.04(0.3)
woman's predicted income (same units)	.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	1871	888	830	153
of which number died				

[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:				
other income (100's of cordobas per fortnight)	.00(0.3)	.00(0.0)	-.01(0.8)	.02(2.1)
woman's predicted income (same units)	.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)	.39(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)
$\bar{R}^2$	.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:				
other income (100's of cordobas per fortnight)	.01(1.0)	.00(0.3)	-.01(1.3)	.03(3.4)
woman's predicted income (same units)	-.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)
$\bar{R}^2$	.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 Bicep 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:				
other income (100's of cordobas per fortnight)	.00(0.9)	.00(0.8)	.00(0.2)	.001(1.7)
woman's predicted income (same units)	.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(0.9)
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.

Table 7. Regression Estimates of Standardized Child Weight, Height and Bicep Circumference for Smaller Combined Sample

Right-Hand Side Variables	Standardized Weight[b/]	Standardized Height[b/]	Standardized Bicep Circumference[b/]
Commodity consumption and income:			
other income (100's of cordobas per fortnight)	-.00(0.2)	-.00(0.4)	.00(0.3)
woman's predicted income (same units)	.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(38.6)
$\bar{R}^2$	.13	.16	.12
F	4.7	6.4	4.5
Sample size	745	745	---

[a/] See note a in Table 1.

[b/] See note b in Table 2.

NOTES

1. In (64) 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 bewteen the child and adult health of an individual. See (1, 29, 30, 57, 58) and the references therein regarding evidence of the link between child and adult health and nutrition status. See (12, 15-21, 23-25, 29, 30, 61, 66, 69, 70) regarding the impact of adult health and nutrition status on adult productivities, earnings, labor force participation and fertility.

2. Edwards and Grossman (36) 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 (13, 15, 65). In (20, 23, 24, 25, 61) 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 (12, 55).

4. This survey was collected as part of an extensive study on the role of women in developing countries. See (12-25, 29, 30, 61, 63-73) for studies completed to date or currently in progress.

5. Warren Sanderson uses these labels in his recent review of the Easterlin, Pollak, and Wachter (EPW, 35) paper on fertility determinants which provides a number of earlier references to "Pennsylvania" studies. The standard references to the seminal Chicago-Columbia school studies include (3, 5, 6). 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 (49), who generally would be classified in the Chicago-Columbia school, incorporate biological factors within a demographic "renewal model" of contraceptive use. Becker and Tomes (6, 7) of the Chicago-Columbia school discuss intrafamilial allocations and intergenerational decisions with a model that is similar in many respects to that developed for similar purposes by Behrman, Pollak and Taubman (10) of the Pennsylvania school. Nevertheless the distinction is useful because of ongoing differences about some important details concerning the endogeniety of preferences, the importance of biological factors, the usefulness of "full" or "social" income measures and shadow prices, etc. Behrman and Taubman (11) review many of these issues.

6. We follow the well-established practice of ignoring the difficult questions 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 chidren 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 within family allocation questions see (6, 7, 10, 13).

8. We ignore bequests and in kind transfers. See (6, 7, 10) 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 (55) study which assumes specific functions for the parental utility and child health functions (ie., 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 United States' 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 below 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 relation. 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 to those in the question of alternative controls for age and length of exposure for fertility variables that we discuss in (17).

15. We qualify our statement about genetic controls with the adverb "paritaly" because we do not believe that the distributions of weights and heights for the base sample for these norms (ie., children in Yellow Springs, Ohio) are independent of environmental factors. They probably are free, however, of subnourishment. See (27 and 74) for further discussion of such indices.

16. In (23, 69, 70) 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 (20, 23, 24, and 61).

18. In (20, 24, 25) 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, vitamin A and iron intakes since these also are in relatively limited supply However the best single measure of nutrient deficiences for our sample is the caloric one, and multicollinearity precludes the inclusion of other measures simultaneously. For further discussion for the central metropolis, see (66).

21. We find some evidence consistent with this pattern for food markets in the central metropolis in (66).

22. In (23, 24, 25) 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.

23. We are exploring the micro determinants of migration in terms of person-specific earnings options, marriage options, and differential public services in (19).

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

25. 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 (9). In (15) we are undertaking a similar investigation for the sample that we use in this study.

26. 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.

REFERENCES

(1) Anthony, Ross. "Health, Population and Income in Rural Nepal." Philadelphia: University of Pennsylvania, unpublished Ph.D. dissertation, 1979.

(2) Antonovsky, Aaron. "Implications of Socio-Economic Differentials in Mortality for the Health System." Paper presented at WHO Meeting on Socioeconomic Determinants and Consequences of Mortality, Mexico City, June 19-25, 1979.

(3) Becker, Gary S. "An Economic Analysis of Fertility" in Universities-National Bureau Committee for Economic Research, Demographic and Economic Change in Developed Countries. Princeton: Princeton University Press, 1960, 209-231.

(4) _____. "A Theory of the Allocation of Time." The Economic Journal 75 (September, 1965), 493-517.

(5) Becker, Gary S. and Lewis, H. Gregg. "On the Interaction Between the Quantity and Quality of Children." In New Economic Approaches to Fertility, ed., by T.W. Schultz. Proceedings of a Conference sponsored by the National Bureau of Economic Research and the Population Council. Journal of Political Economy, 81, No. 2, Part II (March/April, 1973).

(6) Becker, Gary S. and Nigel Tomes. "Child Endowments and the Quantity and Quality of Children." Journal of Political Economy 84 (August, 1976), S143-S162.

(7) _____. "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility," Journal of Political Economy 87 (December, 1979), 1153-1189.

(8) Behm, Hugo. "Socioeconomic Determinants of Mortality in Latin America. Paper presented at WHO Meeting on Socioeconomic Determinants and Consequences of Mortality, Mexico City, June 19-25, 1979.

(9) Behrman, Jere R., Zdenek Hrubec, Paul Taubman, and Terence J. Wales. Socioeconomic Success: A Study of the Effects of Genetic Endowments, Family Environment and Schooling. Amsterdam: North-Holland, 1980.

(10) Behrman, Jere R., Robert A. Pollak and Paul Taubman. "Parental Preferences and Provision for Progeny." Philadelphia: University of Pennsylvania (mimeo), 1980.

(11) Behrman, Jere R. and Paul Taubman. The Role of the Family in Inter and Intra Generational Socioeconomic Inequality: An Economic Perspective. Philadelphia: University of Pennsylvania (in process), 1980.

(12) Behrman, Jere R. and Barbara L. Wolfe. "The Impact of Health and Nutrition on the Number of Surviving Children in a Developing Metropolis." Philadelphia: University of Pennsylvania (mimeo), 1979.

(13) _____. "Parental Preferences and Intrafamilial Allocations of Human Capital Investments in Schooling and Health in a Developing Country." Philadelphia: University of Pennsylvania (mimeo), 1980.

(14) _____. "Wage Rates for Adult Family Farm Workers in a Developing Country and Human Capital Investments in Health and Schooling." Philadelphia: University of Pennsylvania (mimeo), 1980.

(15) _____. "The Returns to Schooling in Terms of Adult Health, Occupational Status, and Earnings in a Developing Country: Omitted Variable Bias and Latent Variable-Variance Components Estimates." Philadelphia: University of Pennsylvania (mimeo), 1980.

(16) _____. "Important Early Life Cycle Socioeconomic Decisions for Women in a Developing Country: Years of Schooling, Age of First Cohabitation, and Early Labor Force Participation." Philadelphia: University of Pennsylvania (mimeo), 1980.

(17) _____. "Human Capital Investments in Women and Fertility in a Developing Country: Extensions to Include Health and Nutrition and to Deal with Incomplete Data Problems." Institute for Research on Poverty Discussion Paper. Madison, Wisconsin, 1980.

(18) _____. "A More General Approach to Fertility Determination: Endogenous Preferences and Natural Fertility in a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(19) _____. "Internal Migration of Women in a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(20) _____. "Sectoral and Geographic Labor Market Segmentation and Earnings Functions in a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(21) _____. "Knowledge and Use of Modern Contraceptives in a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(22) _____. "Fertility Determinants in a Developing Country: Urban-Rural Differentials and Non-Linear Effects." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(23) Behrman, Jere R., Barbara L. Wolfe and David Blau. "Human Capital and Income Distributions in Urban and Rural Areas of a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(24) Behrman, Jere R., Barbara L. Wolfe and Insan Tunali. "Women's Earnings in a Developing Country: Double Selectivity, a Broader Definition of Human Capital to Include Health and Nutrition Status, Discrimination, Pluralism, and Family Status and Child Care." Philadelphia: University of Pennsylvania, (mimeo), 1979.

(25) _____. "Determinants of Women's Earnings in a Developing Country: A Double Selectivity, Extended Human Capital Approach." Madison: University of Wisconsin, (mimeo), 1980.

(26) Ben-Porath, Yoram and Finis Welch. "Do Sex Preferences Really Matter?" The Quarterly Journal of Economics 90:2 (May, 1976).

(27) Berg, Robert L. Health Status Indexes. Proceedings of a Conference conducted by Health Services Research, Tuscon, Arizona, October 1972. Chicago: Hospital Research and Educational Trust, 1973.

(28) Birdsall, Nancy. "Siblings and Schooling in Urban Colombia." New Haven: Yale University, unpublished Ph.D. dissertation, 1979.

(29) Blau, David. "On the Relation Between Child Malnutrition and Economic Growth in Less Developed Countries." Madison: University of Wisconsin (mimeo), 1977.

(30) _____. "Nutrition, Fertility and Labor Supply in Developing Countries: An Economic Analysis." Madison: University of Wisconsin, Ph.D. dissertation, 1980.

(31) Caldwell, J.C. "Education as a Factor in Mortality Decline: An Examination of Nigerian Data." Paper presented at WHO Meeting of Socioeconomic Determinants and Consequences of Mortality, Mexico City, June 19-25, 1979.

(32) Chernichovsky, D. and D. Coate. "An Economic Analysis of Diet, Growth and Health of Young Children in the United States," Cambridge, Mass: NBER Working Paper No. 416 (mimeo), 1979.

(33) Cochrane, Susan H. Fertility and Education: What Do We Really Know? Baltimore: Johns Hopkins Press, 1979.

(34) Davis, Karen and Cathy Schoen. Health and the War on Poverty. Washington, D.C.: Brookings, 1978.

(35) Dyson, Tim. "Levels, Trends, Differentials and Causes of Child Mortality -- A Survey." World Health Statistics Reports 30 (1978), 282-311.

(36) Easterlin, Richard A., Robert A. Pollak and Michael Wachter. "Towards a More General Model of Fertility Determination: Endogenous Preferences and National Fertility" in Richard A. Easterlin, ed., Population and Economic Change in Less-Developed Countries, 1980, 81-140.

(37) Edwards, Linda N. and Michael Grossman. "The Relationship Between Children: Health and Intellectual Development." New York: NBER Working Paper No. 213 (mimeo), 1977.

(38) _____. "Children's Health and the Family." New York: NBER Working Paper No. 256 (mimeo), 1978.

(39) _____. "Adolescent Health, Family Background, and Preventive Medical Care." Cambridge: NBER Working Paper No. 398 (mimeo), 1979.

(40) Habicht, J.P., R.E. Klein, R.M. Malena, R. Martorell and C. Yarbrough. "Height, Weight Standards for Pre-School Children: How Relevant are Ethnic Differences in Growth Potential?" Lancet 1 (1974), 611-615.

(41) Hansluwka, H. "Health, Population, and Economic Development," in L. Tabah, ed., Population, and Economic Development in the Third World, Vol. 1. Dolhain, Belgium: Ordina Editions, 1976, 191-249.

(42) Hu, Teh-Wei. "Effectiveness of Child Health and Welfare Programs: A Simultaneous Equations Approach." Socio-Economic Planning Sciences 7 (1973).

(43) Inman, Robert P. "The Family Provision of Children Health: An Economic Analysis," in Richard Russett, ed., The Role of Health Insurance in the Health Services Sector. New York: Neal Watson Academic Publications for the NBER, 1976.

(44) Leibowitz, Arlene. "Family Background and Economic Success: A Review of the Evidence," in Paul Taubman, ed., Kinometrics: Determinants of Socioeconomic Success Within and Between Families. Amsterdam: North-Holland Publishing Company, 1977, 9-34.

(45) Lewit, Eugene M. "Experience with Pregnancy: The Demand for Prenatal Care and the Production of Surviving Infants." New York: City University of New York, unpublished dissertation, 1977.

(46) Mechanic, David. "The Influence of Mothers on Their Children's Health, Attitudes and Behavior," Pediatrics 33 (May, 1964).

(47) Merrick, Thomas W. "Infant and Child Mortality Differentials in Brazil." Washington: Georgetown University (mimeo), 1979.

(48) Merrick, Thomas W. and Richardo Moran. Brazil: Human Resource Special Report, Annex I, Population. Washington: World Bank Report No. 2604-BR, 1979.

(49) Michael, Robert T. and Robert J. Willis. "Contraception and Perti Household Production under Uncertainty," in Conference on Res of Income and Wealth, Household Production and Consumption. York: NBER, 1976, 27-94.

(50) National Center for Health Statistics. "Growth Charts." U.S. D.H. P.H.S., Health Resources Administration. Rockville, Maryland (HRA76-1120,25,3), 1976.

(51) Pollak, Robert A. and Michael L. Wachter. "The Relevance of the Household Production Function and Its Implications for the Allocation of Time." Journal of Political Economy (April, 1975), 255-277.

(52) _____. "Reply: Pollak and Wachter in the Household Production Function Approach." Journal of Political Economy. (1977).

(53) Preston, Samuel H. "Causes and Consequences of Mortality Declines in Less Developed Countries During the Twentieth Century," in Richard A. Easterlin, ed. Population and Economic Change in Developing Countries. Chicago: The University of Chicago Press for the NBER, 1980, 289-360.

(54) Puffer, Ruth R. and Carlos V. Serrano. Patterns of Mortality in Childhood. Washington, D.C.: Pan American Health Organization, 1973.

(55) Rosenzweig, Mark R. and T. Paul Schultz. "Birthweight, the Production of Child Health, and Input Demand." New Haven: Yale University Economic Growth Center Discussion Paper No. 352, (mimeo), 1980.

(56) Schultz, T. Paul. "Interrelations Between Mortality and Fertility," in R. Ridker, ed., Population and Development. Baltimore: The Johns Hopkins University Press for Resources for the Future, 1976, 239-289.

(57) Selowsky, Marcelo. "A Note on Preschool-Age Investment in Human Capital in Developing Countries," Economic Development and Cultural Change 24 (1976), 707-720.

(58) Selowsky, Marcelo and Lance Taylor. "The Economics of Malnourished Children: An Example of Disinvestment in Human Capital." Economic Development and Cultural Change 22:1 (October, 1973), 12-31.

(59) Seoane, Nichole, and Michael C. Latham. "National Anthropometry in the Identification of Malnutrition in Childhood," Journal of Tropical Pediatric and Environmental Child Health (September, 1971), 98-105.

(60) Tomes, Nigel. "Intergenerational Transfers of Human and Non-Human Capital in a Model of Quality-Quantity Interaction." Chicago: University of Chicago, unpublished Ph.D. dissertation, 1978.

(61) Tuanli, Insan, Jere R. Behrman and Barbara L. Wolfe. "Identification, Estimation and Prediction Under Double Selection." University of Wisconsin, Madison, 1980.

(62) Williams, Anne D. Effects of Economic Development on Fertility: Review and Evaluation of the Literature. Washington: TEMPO, 1974.

(63) Wolfe, Barbara L. "Fertility and Woman's Labor Supply -- A Survey and Suggestions for Applications to a Developing Country." Madison: University of Wisconsin, (mimeo), 1977.

(64) Wolfe, Barbara and Jere R. Behrman. "Determinants of Health Utilization in a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(65) _____. "The Determinants of Schooling for Children in Developing Countries: Family Background, Number of Siblings, Sex, Birth-Order, and Residence." Philadelphia: University of Pennsylvania, (mimeo), 1980.

(66) _____. "The Household Demand for Nutrition Inputs in a Developing Country." Madison: University of Wisconsin, (mimeo), 1980.

(67) Wolfe, Barbara L., Jere R. Behrman, Humberto Belli, and Kathleen Gustafson. "How Many? How Much? The Determinants of Demoeconomic Roles of Women in a Developing Country Metropolis." Madison: Univeristy of Wisconsin, (mimeo), 1979.

(68) _____. "How Many? How Much? The Determinants of Demoeconomic Roles of Women in Small Towns and Cities of a Developing Country." Madison: University of Wisconsin, (mimeo), 1979.

(69) Wolfe, Barbara L., Jere R. Behrman and David Blau. "The Impact of Changing Population Composition on the Distributions of Income in a Developing Country." Madison: University of Wisconsin, (mimeo), 1980.

(70) _____. "The Impact of Demographic Changes which Accompany Long-Run Development on the Medium-Run Distributions of Major Income Components in Urban and Rural Areas of a Developing Country." Philadelphia: University of Pennsylvania, (mimeo), 1980

(71) Wolfe, Barbara L., Jere R. Behrman and John Flesher. "A Monte Carlo Study of Alternative Approaches for Dealing with Randomly Missing Data." Institute for Research on Poverty Discussion paper DP587- 79. Madison, Wisconsin.

(72) Wolfe, Barbara L., Jere R. Behrman and Kathleen Gustafson. "Demo-economic Characteristics of Women and Different Degrees of Urbanization in a Developing Country." Madison: University of Wisconsin, (mimeo), 1980.

(73) Ybarra Rojas, Antonio. La Estructura Occupational de la Fuerza de Trabajo Feminina en Nicaragua, 1950-1977. Managua: Banco Central, 1978.

(74) Zerfas, A.J., I.J. Shon, D.B. Jelliffe, and E.F.P. Jelliffe. "Selected Indicators of Nutritional Status Obtained by Direct Examination." World Health Organization, NUT/EC/75.18, (mimeo) 1975.