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Households, Communities and Preschool Children's Nutrition Outcomes: Evidence from Rural Côte d'Iviore

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Abstract

This paper estimates reduced form equations, derived from an economic model of household production, for child nutrition outcomes in rural Ivory Coast as proxied by height and weight for height. The focus is on the impact of observable household and community level variables, while accounting for unobserved household heterogeneity in the estimation procedure. Such unobserved differences across households is shown to be important. Observable household variables, particularly parental education, are shown to effect (positively) child anthropometric outcomes. Intrahousehold distribution issues having to do with extended African households are also found to be important. Community variables such as the agricultural wage, the incidence of certain diseases, health service quality, and source of drinking water are found to have independent effects.

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This paper reports estimates of reduced form equations for preschool child height and weight-for-height for rural Cote d'Ivoire.[1] Child height is often used as an indicator of long run nutrition status and weight-for-height as an indicator of short run status by nutritionists (see for instance the volume edited by Falkner and Tanner, 1986). They thus have direct implications for household welfare as a component of health. In addition, they may have functional consequences. While the functional consequences of moderately short height or moderately low weight-for-height are debated it is clear that at severely short or low levels serious consequences, such as considerably higher risk of death, can arise (see, for example, Chen, Chowdhury and Huffman, 1980, and the survey by Martorell and Ho, 1984).

It is consequently of interest to model the determination of child nutrition outcomes as measured by height and weight-for-height. In particular, the contributions made by parental education, household wealth, and community characteristics, some of them manipulable by government policy, are of concern for this paper. Their impacts are estimated while accounting for common household-level unobserved variables by using a random effects approach (most households have more than one child in the sample). Fixed household effects estimates for variables which vary within households are also obtained to purge possible correlation between unobserved household characteristics and community variables. Because these households are extended in their organization it is possible to estimate the effect of mother and father-level variables (such as education) in this way. A multipurpose household level data set is used, which contains detailed individual and household socioeconomic information, and in addition has data on many community characteristics. Few prior studies of child nutrition have had available the wealth of such information, particularly on household socioeconomic and community variables.

The results show positive effects for both mother's and father's education on weight-for-height, and positive maternal education effects (though not precisely estimated) on height. The impact of community characteristics is strong. Of these local wage rates, the health environment and the quality of health infrastructure seem to matter most. Unobserved household-level factors are shown to be quite important suggesting the need to account for them in an explicit way. In addition there seem to be strong effects of intrahousehold distribution particularly for children of household heads and their senior wives.

1. Past Studies

There have been a number of past attempts to model nutrition outcomes (see the surveys by Cochrane, Leslie and O'Hara, 1982, Strauss, 1985, and Behrman and Deolalikar, 1986). As pointed out in these reviews many studies have confused the concepts of production function and reduced form, estimating a hybrid of the two. Most have also ignored the economic model of the household (eg. Becker, 1965), which treats households as simultaneously choosing inputs into nutrition such as food consumption, length of breastfeeding or whether inoculations are given. For instance, in a recent paper Martorell, Leslie and Moock (1984) use such household choice variables as the months a child is breastfed and the types of foods eaten to explain height and weight of Nepalese children. Many other examples exist of using such endogenous variables.[2] While those factors undoubtedly belong in a well specified nutrition production function, estimating that function using OLS rather than a simultaneous equations estimator will cause biased, and possibly quite misleading, coefficient estimates. As one example, Martorell, Leslie and Moock find no significant effect of mother's or father's education on height or weight-for-height in their Nepal sample. However they are holding constant variables, such as the type of food eaten and the number of months breastfed, which these education variables could be expected to affect.

A few studies have been more careful to specify what is exogenous and what is not. In a paper closely related in spirit to this one, Rosenzweig and Schultz (1982) estimate reduced form equations for Colombian fertility and mortality outcomes using individual, household and community level variables, as is done here. Pitt and Rosenzweig (1985) use a farm household model to derive reduced form equations for reported illness in Indonesia. Chernichovsky and Coate (1983), Chernichovsky et al. (1983), Blau (1984) and Behrman and Deolalikar (1985) estimate reduced form equations for height and weight. The first three data sets had very few variables to work with, especially on the community side. In the Behrman and Deolalikar analysis which reanalyzed the rural Indian data used by Bidinger et al. (1983), very few strong results emerge for the weight-for-height reduced form equations. Finally Horton (1984, 1986) and Barrera (1987) also estimate reduced form equations for height-and-weight-for-height using data from Bicol, Philippines. Both find stronger effects of parent's education than most previous papers. Horton's 1984 paper is also very closely related to this because she also looks at household fixed effects estimates, in her case of the impact of birth order and its interaction with other variables, on height and weight-for-height.

2. Nutrition Outcomes in Rural Cote d'Ivoire

The Cote d'Ivoire has been generally regarded as one of the few economic success stories in sub-Saharan Africa (World Bank, 1978; World Bank, 1982; Zartman and Delgado, eds., 1984), with a 7.1 percent annual growth rate of GDP from 1965 to 1973 and 3.7 percent from 1973 to 1984 (World Bank, 1986). Even its agriculture sector has grown well, with a sectoral GDP growth rate of about 3.5 percent annually from 1965 to 1984. Yet the Cote d'Ivoire has been widely attacked for lagging in social and health investments as well as for regional inequalities (World Bank, 1978). Looking at indicators of nutritional status for rural children, shown in Table 1, it would seem that nutrition problems in rural Cote d'Ivoire are mild by African standards. In particular, looking at the percent of rural children under six years who are less than 90 percent of median height for U.S. children, a widely used standard of stunting for international comparisons (WHO, 1983), only 10 percent fall in this category in rural Cote d'Ivoire in 1985 as compared to over 20% in surveys taken in the mid-1970's in seven other African countries (see Kumar, 1986). By contrast only 0.5 percent of 2 year old boys in the U.S. fall below this standard (Waterlow et. al., 1977). Some 4.4 percent of Ivoirian pre-school children fall under 80 percent of the U.S. median weight-for-height (compared to 0.6 percent of two year old girls in the U.S.). This is the same percentage as was found for rural Kenya in a 1977 survey (Kumar), however there do exist African countries (such as Cameroon, Liberia and Sierra Leone) with smaller percentages (on the order of 1 to 2 percent) of so-called "acutely undernourished" children. Nonetheless, compared to non-African countries, particularly in Asia, the 4.4 percent figure is low (Kumar). Thus it is not obvious from these data that the nutrition of rural Ivoirian children, as measured by their height and weight-for-height, is poor, at least by African standards.

Nevertheless substantial variation does exist within the country. Separating the rural area into regions, for instance, nearly 15 percent fall under the 90 percent of U.S. median height standard in the northern part of the country (the Savanna). This area is drier and has considerably lower incomes than in the south (see Table 2), which is the backbone of the rural treecrop economy --- mostly coffee and cocoa. In the relatively wealthier eastern rural area, part of which is near the capital city of Abidjan, that percent falls to just under 7.

The purpose of this paper, then, is to examine the extent to which such differences can be explained by such regional factors as local wage rates, health, schooling and water infrastructure; by such household level factors as land availability or wealth; and by parental factors, notably education of each of the parents and parental height.

3. Model

The reduced form equations for children's anthropometric measurements can be derived from a model of a multimember household in which production and consumption choices are made. The basic model for one-person farm households is outlined in Singh, Squire and Strauss, 1986. An extension incorporating a health production function and multiple household members is provided in Pitt and Rosenzweig (1985), and that is the approach followed here. Since the model is only used to provide guidance on the choice of exogenous and endogenous variables only a cursory overview will be given.

The household behaves as if maximizing a long run utility function[3] having as arguments the nutritional and morbidity status (including height and weight-for height) of each member, each person's leisure time, consumption of a bundle of foods, and consumption of non-food. Health and nutritional status of the household members as well as food consumption enter directly into the utility function because good health is desirable in itself and because foods are consumed partly for reasons other than their nutritive values.

Four sets of constraints face these households. Each individual faces a time constraint. There is the usual household budget constraint in which individual market labor supplies are taken to be choice variables. There is a farm production function, and finally there exist nutrition and morbidity production functions. The nutrition production functions, particularly for height and weight, should ideally be represented in terms of changes, or growth, since both height and weight are stocks.[4] Growth can be represented as a function of past levels and growth of height (or weight), of current morbidity, food intake, and energy expenditure, as well as on individual and parental characteristics (including time use), some of which are observed in the data and some not. Given a function for initial conditions, i.e., birthweight and length, the technology would be closed. Similarly a production function exists for current morbidity, which may include the current morbidity of other household members and health inputs such as innoculation and consumption of medicines, in addition to inputs in the nutrition production function.

Modeling nutrition outcomes in terms of flows rather than stocks results in the derived reduced forms for the stock variables including lagged exogenous variables as arguments.[5] These exogenous variables include five categories: individual level variables such as age and sex; parental variables such as education, age, and height; household level "exogenous" variables such as land area and production assets (or non-labor income)[6]; community-level variables having to do with the cost of using (and information concerning) health and schooling facilities; and community prices of consumption items such as foods, nonfoods, and leisure. Many of these variables, such as parents education, will be time invariant. The community variables may change over time as new investments in facilities are made or as prices change. In this paper only young children are considered which should mitigate the absence of lagged exogenous variables. Regarding community infrastructure variables, national community rankings in terms of infrastructure typically change only slowly. That is high infrastructure communities tend to remain so, certainly over short time horizons as exists in these data. The same argument applies, though to a lesser extent, to food prices and wages.

A potential complication which needs discussion has to do with the two assumptions implicit in treating the community level variables as exogenous. Health and schooling infrastructural investments may depend on underlying community factors such as income and distance to major towns which are correlated with the unobserved household effects. If, for instance, hospitals are located in healthier areas for both demand (incomes are higher) and supply (they are near towns where costs are lower because of greater infrastructure such as electrification) reasons, then one would expect a negative correlation between distance to a hospital and nutrition outcomes. This correlation would have resulted from both variables being correlated with the underlying community factors (see Rosenzweig and Wolpin, 1986). A second potential complication is that households may selectively migrate partly in response to different health and schooling infrastructure of communities. This too would cause a correlation between unobserved household effects and community variables as shown by Rosenzweig and Wolpin (1984). It is not clear whether these two sources of correlations between community and unobserved household variables will be important for the Cote d'Ivoire sample. It is, however, a testable hypothesis.

One way to eliminate the impact of unobserved household heterogeneity is to estimate a household fixed effects model. This is one approach taken here. Unfortunately, community-level variables are eliminated by that procedure, although not interaction terms between community variables and variables varying within a household. Provided correlation does not exist between community variables and unobserved household factors a household random effects model can be estimated using community variables. This will result in more efficient estimates than OLS provided that there is more than one child under six years in most households.[7] Given both random and fixed effects parameter estimates, the hypothesis of no correlation between community variables and the underlying error structure can be tested using a Wu-Hausman specification test.

4. Data

The data were collected by the World Bank's Living Standards Measurement

Studies unit in collaboration with the Department of Statistics of the Ministry of Finance in Cote d'Ivoire (see Ainsworth and Munoz, 1986, and Grootaert, 1986, for a detailed description). A national probability sample of 1600 households were visited twice two weeks apart, out of which 636 households had height and weight measurements taken, in principle, of all household members.[8] Of these households, 365 reside in rural villages, and since community data were only collected for rural communities, the analysis is limited to these households. There are 657 children under six years who are residing members of these households, and of those 608 (92.5%) were measured.[9] Of the children measured, 85 children are dropped because no measurements were taken on their mothers, either because the mothers do not live in the household or because they were absent during the two interviews.[10] Finally some 19 children had to be dropped because of incomplete data, leaving a sample size of 504 for analysis.

Heights and weight-for-height are standardized using the age-sex specific median from the U.S. NCHS standards (see WHO, 1983). Evidence exists from a number of developing countries (see Habicht et al., 1974, and Martorell and Habicht, 1986) that heights for well nourished children in developing countries (outside of east Asia) are close to the NCHS median, while heights of poorly nourished children are not. The coefficients which will thus be most affected by the standardization are those on the child age dummies and on child sex. These will have to be interpreted as the effects relative to the U.S. standard.[11]

Mother's height is also standardized using NCHS standards. Standardizing adult heights raises more questions than for children because of ethnic differences in the onset and length of the adolescent growth spurt. Standardization is used here to try to control for mothers who are still adolescents, between 13 and 17. For those greater than 17 years the same (sex specific) standard is used.

The per capita asset variable is calculated as cultivated land per adult. The percent of cultivated land planted to treecrops is a crude attempt to proxy for agro-climatic conditions. Coffee, cocoa, coconut and oil palms are major sources of agricultural income, typically with higher net returns than food crops, but can only be growth in more humid areas found in the southern part of the country.

Asset variables are used rather than nonlabor income for two reasons. First the nonlabor income, which includes both net farm and nonfarm enterprise returns (but not subtracting the value of family labor), has major measurement problems.[12] Second, essentially all of the children reside in farm households. For such households farm income net of family labor would be uncorrelated with unobserved household effects provided the household's production and consumption decisions were recursive, or separable (see Singh, Squire and Strauss, 1986, and Pitt and Rosenzweig, 1985, for an application). However if production also depended on consumption decisions, as it would if health or nutrition of adults entered the farm or nonfarm production functions, then net returns would be correlated with the child nutrition reduced form disturbance and thus raise a simulataneity issue. Third, as stated, the appropriate concept in a recursive model are the returns netting out household labor, unless family labor supply is assumed to be fixed. Complete household labor data are not available for own account farm or non-farm enterprises making construction of such a variable impossible.

The community-level variables were obtained independently from the household level information by interviewing a group of village elders, including the chief, (Ainsworth and Munoz). These variables represent the overall availability of various services within a village, thus proxying for prices and information. Data on the service use of each household, although available, is not used because it reflects household choices.[13]

The distance variables are from the village, not each individual household.

The water source dummy variables show the dominant village source (only one per village) for the rainy season (there are a few, but not many differences during the dry season). The omitted category includes both private tap connections and village wells with pumps. Natural sources include rain, lakes, and rivers.

The major community health problem and health service problem data were derived from two open ended questions which asked about the four major health or health service problems. Answers were subsequently coded into dummy variables based on whether or not a disease or service problem was mentioned as being one of the four. Not having medical problems was the omitted category. A large proportion of villages gave no answer, which may or may not indicate absence of problems. It is resonable to presume that those villages reporting such problems are seriously affected.[14] Unfortunately more objective epidemiological information is not available except in the form of hospital reports. Since hospitals can only report cases when someone has sought treatment any probabilities based on such cases will be biased.

For the health service problem variable there are very few villages which did not provide answers, although the answers might be modeled as an outcome of an information process (see footnote 14).[15] Absence of medicines was coded as a separate response as was having congestion problems (not enough room) at the nearest hospital. Water problems include not having drinking water, no sanitation services or no well. The residual category is comprised of no problem or having no services. The latter is already accounted for by the distance variables.

The interactions between mother's education and the community variables, particularly the distance variables, are designed to capture substitutability or complementarity between provision of these public services and education (see Rosenzweig and Schultz, 1982). Mother's education is used since the mother's time is likely to be intensively used (relative to the father's) in childrearing. In addition to capturing technical relationships between education and use of health, education and water services in the nutrition production function, these interactions will also capture inequality of access to the extent it exists and is related to education levels of the household. Access to public services has been a policy issue of concern, particularly at the World Bank (see, for instance, Selowsky, 1979).

Sample variable means and standard deviations are reported in Table 2 for all of rural Cote d'Ivoire and broken down by three regions: East Forest, West Forest and Savanna. Table 2 indicates the decline in resources from the East Forest to West Forest to the Northern Savanna. The Savanna in particular has very few educated parents, little land planted to the lucrative tree crops of coffee and cocoa, and a consequent low male agricultural wage rate. Reported disease problems are also much more common there. These differences in resources are reflected in lower standardized heights and weights for height, both for children and their mothers.

5. Results

A. Household Fixed Effects Estimates

Table 3 reports the specifications for the household fixed effects model. There are 211 households represented by the 504 children. Because many of these households are extended, many contain children having different parents (there are 320 mothers). In consequence the mother level variables do not get swept out by the differencing procedure. Three specifications are reported in this table, columns (1) contain estimates which omit the interactions between community variables and the mother's education dummy. Columns (2) adds two household organization variables: whether the child's mother is the senior wife of the household head (or household head in a female headed unit) or the junior wife. The left out category is not being a child of the household head.[16] These variables potentially represent effects of intrahousehold distribution, which has not been carefully examined using African data.[17] While household formation might reasonably be treated as endogenous, indeed results reported below are consistent with this interpretation, the fixed effects setting estimation removes unobserved household level effects, a major source of endogeneity. The third specification, columns (3), add the community infrastructure—mother's education interactions.

The effects of both mother's and father's education are nonlinear, the impact being negligible until the fourth year.[18] The education coefficients are stronger for weight for height than for height. Mother's education does have a small positive effect on height, which is consistent with a role for mother's education outside of producing income.

Mother's height has an important impact on child height but none (the point estimate being slightly negative) on weight for height. Mother's height encompasses both genetic and human capital investments — the latter including mother's nutritional status during pregnancy. The negative coefficient in the weight for height equation seems inconsistent with an interpretation of mother's height as only proxying for underlying unobserved health endowment. On the other hand a pure genetic effect does not seem to fit well either, since when father's height is added on a considerably reduced sample[19] the mother's height coefficient retains its magnitude and significance but the effect of father's height is imperceptible (a coefficient of —.11 and t—statistic of .3). While a lower impact of father's as compared to mother's height on infant length is found on the medical literature (see Garn and Rohman, 1966 or Mueller, 1986), height of older children are usually associated with both parents' height.

The child age coefficients suggest a reduction in height, relative to U.S. median children starting at six months, accentuated at around two years and bottoming out around four years. This is a typical pattern in developing countries,[20] which may be related to the introduction of solid foods and the termination of breast feeding.[21] For weight for height the relative reduction begins at six months, bottoming out at two years.

A male sex dummy is not significant. The coefficient is actually negative for both height and weight for height, but negligible in magnitude. Sex bias relative to U.S. standards has not been found in other anthropometric surveys in sub-Saharan Africa (see Svedberg, 1987), nor has it been found there in child mortality rates.

Having a mother who was under 18 years at birth is associated with worse anthropometric outcomes, with a p-value of under .05 for weight for height, but not significant for height. This is holding constant her height relative to age-specific standards as well as her education. The effect seems to be very non-linear, ending at age eighteen.[22]

Being a child of the senior wife of the household head has a positive impact with similar magnitudes on both height and weight-for-height, though only the effect on height is precisely estimated. Being a child of the junior wife has essentially the same impact on weight-for-height as does senior wife, suggesting that it is being a child of the household head which is making the difference here (not being a child of the head being the omitted category). For height outcomes this does not seem to be the case however; being a child of the senior wife is associated with a higher height than is being a child of a junior wife. The senior wife's children are likely to have been born earlier than those of the junior wife, when household resources may not be so stretched from any unplanned births. Apparently this disadvantage gets eliminated over time, which is reflected in improved weight-for-height, but not height. This result is very similar to Horton's (1986) result of the effect of birth order[23] on height and weight-for-height for children living in the Bicol region of the Philippines.

The interactions of distances to health and schooling facilities with maternal education fail to be significant at standard levels; F-statistics are 0.5 for the height regression and 0.3 for weight for height. This partly reflects the unimportance of these distance variables in explaining child anthropometric outcomes (see the random effects section), and partly the low level of education in rural areas, especially in the Savanna. The negative coefficients imply a complementarity of these services with mother's education.

B. Mother Fixed Effects Estimates

The last set of columns provide estimates when mother level fixed effects are used rather than household level effects. The question here is do the mother specific variables used in the household fixed effects specification carry most of the mother-related information. This is addressed by an F-test, possible since the child level variables (the age and sex dummies) are in both the household and mother effect specifications, while all the other variables in the household effects case (including father's education and the household head dummy) take on identical values for a given mother.[24] The F-statistics are 1.04 for the height equation and 0.94 for the weight-for-height equations with 104 and 177 degrees of freedom. Neither is significant at the .10 level.

By contrast, testing the household fixed effects against OLS estimates with community and household level variables (or alternatively, with community fixed effects with household variables) show the household effects add significantly, with p-values under .01 for the height equation and at .05 for the weight/height equation (F-statistics of 1.51 and 1.34 respectively for the non-interaction specification with 195 and 281 degrees of freedom).

In consequence it is reasonable to conclude that while unobserved household level effects are clearly important in these reduced form child height and weight/height equations, unobserved mother effects are not.

C. Random Effects Estimates

Household level random effects estimates are reported in Table 4. Three sets of estimates appear there. Columns (1) contains estimates which omit community level variables and interactions. While this specification is incorrect given the presence of community effects exogenous to the household, it may serve as a useful benchmark since many previous studies have likewise used only individual and household level variables. Columns (2) and (3) report estimates adding community variables both with and without interactions with mother's education. All regressions are run excluding the child of senior or junior wife variables because Wu–Hausman specification tests indicate correlation between explanatory variables and the household random effects when these household composition variables are included. Chi–square statistics for the specification tests in this case (excluding interactions) are 24.8 (12 degrees of freedom) for height and 10.3 for weight for height. While the latter statistic is not significant at usual levels the former has a p–value of under .025. Omitting the two wife variables, however, results in test statistics of 14.6 and 8.5 (with 10 degrees of freedom) respectively for the height and weight for height regressions. Neither is significant at the .10 level or better. This suggests that these two variables are the source of mispecification, consistent with viewing household formation as being subject to household choice.[25]

When community variables are excluded child age and mother's height have strong impacts. The percent of land in treecrops is positively related to height, as are land, mother's education and age at birth to weight–for–height. None are very precisely estimated however. When community variables are added the percent of land in treecrops variable loses significance, its coefficient being reduced by one third, while coefficients for parental education, maternal stature and age at birth, and land per adult all rise in levels and significance. Comparing the weight-for-height and height equations the impacts of parental education and land area cropped are larger for the former, suggesting a larger income effect there.[26] Maternal education has a greater effect than does father's for both outcomes, though the difference is not statistically significant. This is consistent with the hypothesis that maternal education affects child nutrition in ways different from a pure income effect. Mother's age at birth, if less than 18 years, continues to have a positive effect on weight for height, as was the case for the fixed effects estimates.

The community variables are jointly significant with p-value less than .01 for height (F-statistic of 2.41 with 13 and 478 degrees of freedom) and at the .15 level for weight-for-height (F equal to 1.47), with many being individually significant at the .05 level. The daily male agricultural wage is significant at the .05 level with an elasticity of .034 for height and .055 for weight-for-height. Consistent with the coefficients for household level variables the income effect is larger for weight-for-height than for height. The coefficients imply that if the daily wage in the poorer Savanna region should rise from its mean of 463 CFA to 648 CFA, the mean in the wealthier East Forest, that mean children's height would rise by 1.2 percent and weight for height by 1.7 percent. The implied rise in predicted standardized heights is from 96.6 to 97.8 percent of the U.S. median which would put heights on par with those in the West Forest region. For weight for height it is from 95.5 to 97.2 percent approximately the mean level of weight for height in the East Forest.

The effects of distances to health facilities or primary schools are negative as expected except for distance to nurse in the weight-for-height equation, but insignificant in either equation. This negative impact could be related to the extra time cost of using the facilities when they are situated farther away, the potential loss in information, or unobserved community health infrastructure being proxied by these distances. Jointly the distance coefficients are not significant at any standard level; moreover the magnitudes of their coefficients are small. The height distance elasticities are —.002, —.003 and —.001 for doctor, nurse and primary school distances, while the weight—for—height elasticities are —.006, .005, and —.0006 respectively.

What seems to have a larger impact than distances judging by the coefficient magnitudes (as well as significance levels) are the quality of service dummy variables. Not having medicines available, having water or sanitary problems, or congestion at the closest hospital have large impacts, particularly on weight—for—height. This would be expected if the frequency or intensity of disease in the community is higher as a consequence, and is supportive of the notion, advanced by Birdsall et al. (1983), that health service quality is critical to the demand for health services, although here we see the impact on an outcome variable rather than an on input.

In addition to the health service problem dummies, indicators for malaria, dysentery, or measles and chickenpox being major community health problems are also important. Malaria especially has a large impact, being associated with shorter heights by 2.5 percent and lower weight—for—height by 6.5 percent.

Three additional community variables are considered. The absence of a traditional healer is associated with better nutrition outcomes. Relying on wells without pumps (used largely in the West Forest) as the main rainy season water source is associated with smaller heights and lower weight—for—heights than is having private taps or wells with pumps, while use of rainfall, rivers or lakes (concentrated mostly in the northern Savanna) does not seem to have much impact, holding other regional factors constant. It is not necessarily the case that wells without pumps will be a better quality source of water than natural sources, and these result suggest that they are not. Much depends on well depth, well construction (such as the lining), whether livestock are kept away, as well as on the quality of the area underground water supply.

As is the case for the fixed effects estimates, the interactions between mother's education and the community variables are not significant at standard levels in either equation (F–statistics of 0.5 and 1.2). The coefficient signs remain negative for weight–for–height but are positive for height.

6. Explaining Interregional Differences in Child Nutrition Outcomes

There exist clear interregional patterns in child nutrition outcomes as well as in income, education and infrastructure (Table 2). The random and fixed effects estimates indicate that observable household and community characteristics do indeed explain part of this variation. The implications of improving household and community characteristics as a group are explored by interchanging these characteristics between representative households in the East Forest and Savanna, two regions which represent contrasting levels of living and infrastructure.

Predictions of the log of standardized height and weight for height for a representative household in each region are shown in Table 5. In making the predictions, account was taken of the random effects (see Taub, 1979).[27] The second row of Table 5 shows the effect of exchanging parental and household characteristics, while keeping constant child (age and sex) and community variables. Row three contains predictions using community characteristics of the other region, but using parental, household and child characteristics of their own region.

For height, observed community variables explain much of the difference in predicted standardized height between the Savanna and the East Forest. The predictions imply that a child with household and child characteristics of the average East Forest household but living in conditions of the Savanna would be 97.2

percent of U.S. median height, rather than 98.9 percent. Likewise children in the Savanna exposed to the improved infrastructure of the East Forest would have heights higher by 1.6 percent. Observed household characteristics have some effects on the height predictions, but not as large as for community effects. This reflects the small magnitudes of the random coefficient coefficients for the height equation. It should be pointed out that this is the effect of observed household characteristics. As indicated by the fixed effects results the effect of unobserved household level characteristics is large. This effect does not show up strongly in these predictions because household effects are being averaged, and there is little correlation between household effects and region (as per the Hausman-Wu tests).

The weight for height predictions show a different pattern. Now observed household characteristics have a rather large joint impact, while community characteristics as a group have only a small effect. While individual community characteristics, such as the male agricultural wage or the reporting of malaria as a health problem, have strong effects, some work in opposite directions.

7. Conclusions

Reduced form equations for preschool child height and weight-for-height show that unobserved exogenous household effects play a critical role in determining outcomes. Controlling for such effects there is a positive impact of mother's education on height and both mother's and father's education on weight-for-height. There is evidence for differential outcomes depending on whether the child is of the head of household or his senior wife. There are strong associations between child nutrition outcomes and a set of community variables such as local agricultural wage rates, quality of health services, underlying disease problems, as well as source of drinking water. Distances to health and school infrastructure on the other hand, while negatively related to child nutrition have a very weak impact. The evidence available from these data is consistent with a causal effect of these community factors.

Footnotes

[1]Cote d'Ivoire (Ivory Coast) is the official name.

[2]Wolfe and Behrman (1982) include average caloric intake, use of refrigeration and length of breastfeeding as regressors in a child height equation using Nicaraguan data. Ryan, Bidinger, Rao and Pushpamma (1983) use energy and protein consumption, weight, arm circumference, evidence of morbidity signs and labor market participation of the mother in explaining height of rural Indian children. Battad (1978) also uses a food consumption variable on a rural Philippine sample, and Longhurst (1984) uses child immunization, breastfeeding, medical history and birth order variables on rural Nigerian data. Even Heller and Drake (1979), who treat illness as endogenous, take food consumption, lagged height and weight, lagged illness, age at weaning, birth order and birth interval as exogenous in an analysis of Colombian children. Other studies, mostly by nutritionists, just use crosstabs, not regression analysis. Some of these are summarized in Martorell and Habicht (1986).

[3]In principle, a dynamic problem with a dynamic nutrition production function would be the appropriate approach. With only cross-section data estimating such a model is not possible.

[4]The same issue arises for educational production functions. Hanushek (1979) discusses this issue well.

[5]A second year of data will allow for reduced form and production function equations for growth to be estimated at a later date.

[6]With a time persistent unobservable such as land or management quality in the farm production function, asset accumulation may be correlated with the reduced form equation error term, which will include these unobserved farm heterogeneity effects. This is ignored here.

[7]Only 57 children out of 504 in the sample have no siblings under six years old.

[8]The anthropometric measurements did not begin until seven months into the survey. Communities were in principle randomly distributed across months in data collection, so that the households with measurements taken should be close to a random sub-sample of the entire sample.

[9]The percentage measured is slightly higher for boys than girls (93% vs. 90%) and is reasonably stable across the 0–6 year age group. These are high percentages in a developing country. Since the children are preschoolers school is unlikely to be a factor in their absence. While a potential selectivity issue is thus raised, nothing is done to correct for that in these results. Partly this is because it is not obvious what instruments are available for identifying the selectivity equation parameters other than functional form assumptions.

A slightly different issue is that some 91 children under 6 are living elsewhere, usually with relatives, despite their being family members. Sending chidren to live with relatives, fostering, is not unusual in Africa. As one would expect, the proportion of children living outside the household rises with school age, though this is not a factor for these results on preschool aged children. Counting those children residing elsewhere, 81% of all living children under six years were measured.

[10]These include children who are fostered in. Comparing variable means between the two groups shows a difference in mother's education, with the absent mothers having slightly more. Given the importance of mother's height in the height equation it was considered that the omitted variables bias in excluding mother's height but including the extra 85 children would be greater than any selectivity bias from excluding children of unmeasured mothers.

[11]Regressions using the unstandardized height and weight–for–height were run, including a cubic spline in child age, with the coefficients for variables other than child age and sex essentially unchanged.

[12]The value of self–produced food consumption was derived by using purchase prices, an upperbound to the shadow value. In addition only a one week reference period was used, which ignores seasonal variations which can be considerable. The income from non farm self–employment is also weak, being based on retrospective rather than prospective interviews.

[13]Food prices, are omitted because of missing data. This does not affect the household fixed effects estimates since they are eliminated by the within household differencing.

[14]One can think of the reported health problems variables as an outcome of an information process which is a function of the underlying true community health state, health services provided to the community, and the average level of education in the community.

[15]More objective information on characteristics, such as number of beds and pharmaceutical budget of the nearest hospital, and regional dispensary information are currently being collected independently of the LSMS survey. They will ultimately be matched to these data and be used in further work.

[16]Separating being a child of the senior wife of a head with one wife or of a head with multiple wives shows no statistical improvement in fit at the .10 level and so was not incorporated.

[17]An exception is a study of child heights in Gambian rural households showing a positive effect of being a child of the household head (Von Braun, Puetz and Webb, 1987).

[18]Results including dummies for both 1–3 years and 4 or more years of education, not reported, indicate this.

[19]To include father's height it is necessary to drop an additional 103 children whose fathers were not measured. Not only is sample size thus reduced, but its characteristics, particularly for parents' education is drastically altered. The percent of children having mothers with a fourth grade education or more declines from 13 to 5 while the percent with fathers having 4 years or more education falls from 21 to 13. Given the unimportance of father's height in the reduced sample and the enormous reduction in variation of the education variables, not to mention the greater possibility for contamination of random effects results because of selectivity bias it was decided to drop father's height while retaining the larger sample.

[20]See, for instance, the review of African evidence by Svedberg (1987) or the work of Barrera (1987) for the Philippines.

[21]By six months 81 percent of children are still being breastfed, which declines to 51 percent by twelve months, 23 by eighteen months, and 4 by two years. No information is available on the timing of introduction of solid foods.

[22]Using mother's age at the time of the survey gives very similar results. Age at birth is reported because it is easier to interpret.

[23]A pure mother birth order variable is available for only a very small subset of the children so it was not possible to use it in the analysis.

[24]We can think of two equations where i indexes households, j indexes mothers and k indexes children:

$$1)\quad y_{ijk} = Z_{ij}\beta + X_{ijk}\theta + \alpha_i + \epsilon_{ijk}$$

$$2)\quad y_{ijk} = X_{ijk}\theta + \mu_{ij} + \pi_{ijk}$$

The vector of mother specific variables, Z_{ij}, and the household dummies, α_i, are contained in the column space of the mother dummy variables, the μ_{ij}'s. Equation 1 is therefore nested within the second equation so an F–test will be a likelihood ratio test in this case.

[25]Choices include whether to extend the household vertically, by living with parents; or hoizontally by being polygynous (see Amyra Grossbard, 1976 for an economic analysis) or living with siblings.

[26]When the land variables are replaced by non–market income (by netting out the

value of family labor) the results are very similar. F-statistics of the joint significance of non-market income and its square are 1.27 for height and 1.91 for weight for height (p-values of .28 and .15 respectively).

[27]To compute the prediction it is necessary to use the number of observations (measured children) in the representative household. For this an average was taken over each region separately. The prediction is then

$$\hat{y}_r = \bar{X}_r\hat{\beta} + \frac{N_r\hat{\sigma}_\mu^2}{\hat{\sigma}_\epsilon^2 + N_r\hat{\sigma}_\mu^2}\bar{\hat{e}}_r$$

where r indicates region, $\bar{\hat{e}}$ is the average residual for a region, $\hat{\sigma}_\epsilon^2$ is the estimated variance of the child specific error term and $\hat{\sigma}_\mu^2$ is the estimated variance of the random household effect.

TABLE 1

PRESCHOOL CHILD NUTRITION INDICATORS FOR RURAL COTE D'IVOIRE[a]

	All Rural	East Forest	West Forest	Savanna
Percent of NCHS median ht.	98.2 (7.2)	99.1 (6.5)	98.0 (7.7)	97.2 (7.4)
Percent of NCHS median wt. for ht.	96.6 (10.6)	97.7 (10.4)	95.5 (11.9)	96.1 (9.8)
Percent less than 90% of NCHS median ht.	10.5	6.8	10.6	14.9
Percent less than 80% of NCHS median wt. for ht.	4.4	4.1	4.7	3.4

[a] Using full rural sample of 608 children less than 72 months old. Standard errors are reported in parenthesis.

TABLE 2

VARIABLE MEANS AND STANDARD DEVIATIONS: BY REGION

Variable	All Rural Mean (sd)	East Forest Mean (sd)	West Forest Mean (sd)	Savanna Mean (sd)
Age (mos.)	32.0 (19.1)	33.8 (19.4)	29.9 (18.5)	31.7 (19.1)
Standardized Height (percent) - All ages	97.9 (7.1)	99.3 (6.8)	97.7 (7.2)	96.7 (7.1)
Age < 6 mos.	100.5 (5.8)			
6 mos. ≤ Age < 24 mos.	99.3 (6.7)			
24 mos. ≤ Age < 48 mos.	96.6 (7.5)			
48 mos. ≤ Age < 54 mos.	96.4 (6.9)			
54 mos. ≤ Age < 72 mos.	98.4 (6.8)			
Standardized Weight (percent) - All ages	96.4 (10.9)	97.6 (10.4)	95.2 (12.6)	96.0 (10.0)
Age ≤ 6 mos.	101.9 (10.9)			
6 mos. ≤ Age < 24 mos.	92.8 (12.0)			
24 mos. ≤ Age < 48 mos.	97.0 (10.3)			
48 mos. ≤ Age < 54 mos.	95.7 (10.4)			
54 mos. ≤ Age < 72 mos.	97.7 (9.3)			
Log of standardized child height[a/]	-.024 (.07)	-.010 (.07)	-.027 (.07)	-.036 (.07)
Log of standardized child weight/height[a/]	-.043 (.12)	-.030 (.11)	-.058 (.14)	-.046 (.11)
Age ≥ 6 mos.	.91	.92	.91	.89
Age ≥ 24 mos.	.67	.71	.63	.66
Age ≥ 48 mos.	.31	.35	.27	.31
Age ≥ 54 mos.	.19	.23	.14	.18
Male child	.52	.52	.55	.50
Log of standardized mother's height[a/]	-.036 (.04)	-.029 (.04)	-.039 (.04)	-.041 (.03)
Mother's education ≥ 4	.13	.20	.17	.01
Father's education ≥ 4	.21	.32	.33	.01
Mother's age at birth (years)	27.9 (8.4)	28.5 (8.7)	27.1 (8.3)	27.9 (8.0)
Child of senior wife	.43	.36	.53	.43
Child of junior wife	.21	.23	.20	.21
Land per adult (hectares)	1.14 (1.09)	1.18 (1.00)	1.22 (1.37)	1.04 (0.96)
% land in treecrops	.45	.59	.68	.13

TABLE 2 (continued)

Variable	All Rural Mean (sd)	East Forest Mean (sd)	West Forest Mean (sd)	Savanna Mean (sd)
Community level variables:				
Male daily agricultural wage (1000CFA)	.549 (.20)	.648 (.21)	.524 (.04)	.463 (.19)
Distance to doctor (100km)	.31 (.24)	.27 (.11)	.36 (.21)	.32 (.33)
Distance to nurse (100km)	.12 (.10)	.05 (.10)	.16 (.09)	.16 (.08)
Distance to primary school (100km)	.002 (.01)	.001 (.003)	.007 (.01)	0.0 (0.0)
Traditional healer in village	.89	1.0	.58	1.0
Well without pump	.21	.18	.57	0.0
Natural sources	.44	.14	.43	.76
Major community health problems:				
Malaria	.15	.12	0.0	.29
Dysentery	.13	.12	0.0	.24
Measles, chicken pox	.13	0.0	.23	.18
Major community health service problems:				
No medicines	.07	.10	.10	0.0
Water problems	.28	.31	.53	.06
Congestion	.15	.27	0.0	.12
Sample Size	504	191	128	185

[a]/NCHS standards are used.

TABLE 3

HOUSEHOLD AND MOTHER FIXED EFFECTS ESTIMATES

Variable	Height/Age[a] Household Effects (1)	Height/Age[a] Household Effects (2)	Height/Age[a] Household Effects (3)	Height/Age[a] Mother Effects (4)	Weight/Height[a] Household Effects (1)	Weight/Height[a] Household Effects (2)	Weight/Height[a] Household Effects (3)	Weight/Height[a] Mother Effects (4)
Child age ≥ 6 mos.	-.022	-.021	-.020	-.027	-.082	-.080	-.083	-.097
	(1.53)	(1.52)	(1.42)	(1.46)	(3.49)	(3.41)	(3.47)	(2.83)
Child age ≥ 24 mos.	-.027	-.029	-.030	-.029	.051	.050	.052	.075
	(2.96)	(3.21)	(3.22)	(1.29)	(3.41)	(3.28)	(3.34)	(1.82)
Child age ≥ 48 mos.	.024	.023	.022	.020	-.034	-.037	-.038	-.009
	(2.02)	(1.95)	(1.92)	(0.95)	(1.76)	(1.89)	(1.92)	(0.23)
Child age ≥ 54 mos.	-.002	-.003	-.003	-.009	.047	.047	.048	.052
	(0.16)	(0.25)	(0.23)	(0.49)	(2.12)	(2.12)	(2.12)	(1.61)
Male child	-.003	-.007	-.008	-.002	-.0002	-.001	.0002	.002
	(0.45)	(.090)	(1.02)	(0.28)	(0.02)	(0.10)	(0.01)	(0.13)
Log mother's standardized	.475	.478	.504		-.127	-.125	-.150	
height	(3.03)	(3.09)	(3.20)		(0.49)	(0.48)	(0.57)	
Mother's education	.021	.025	.056		.043	.047	.040	
≥ 4 years	(1.21)	(1.43)	(1.45)		(1.47)	(1.59)	(0.61)	
Father's education	.002	.002	.0007		.059	.064	.066	
≥ 4 years	(0.15)	(0.11)	(0.04)		(2.33)	(2.49)	(2.54)	
Mother's age at birth	.003	.002	.003	.005	.026	.026	.026	.036
	(0.48)	(0.36)	(0.41)	(0.29)	(2.26)	(2.22)	(2.21)	(1.16)
(Mother's age at birth-18)*	-.003	-.003	-.004	-.008	-.027	-.027	-.027	-.030
Dummy = 1 if ≥18 years	(0.42)	(0.41)	(0.49)	(0.28)	(2.24)	(2.25)	(2.23)	(1.16)
Child of senior wife		.033	.031			.028	.029	
		(2.21)	(2.10)			(1.14)	(1.15)	
Child of junior wife		-.007	-.006			.030	.031	
		(0.40)	(0.37)			(1.10)	(1.12)	
Interactions with mother's education:								
Distance to doctor (100km)			-.220				.209	
			(0.76)				(0.43)	
Distance to nurse (100km)			-.300				-.371	
			(0.65)				(0.47)	
Distance to primary school (100km)			-.588				-3.388	
			(0.15)				(0.53)	
R^2	.58	.60	.60	.75	.54	.55	.55	.71
Standard error	.062	.062	.062	.061	.103	.103	.104	.104
N	504	504	504	504	504	504	504	504
Number of effects	211	211	211	320	211	211	211	320

[a]Log of standardized measure using NCHS standards.

TABLE 4

HOUSEHOLD RANDOM EFFECTS ESTIMATES

	Height/Age a/			Weight/Height a/		
	(1)	(2)	(3)	(1)	(2)	(3)
Age $\geq$ 6 mos.	-.019	-0.15	-.016	-.098	-.092	-.091
	(1.60)	(1.30)	(1.37)	(5.09)	(4.78)	(4.69)
Age $\geq$ 24 mos.	-.026	-0.30	-.030	.050	.048	.046
	(3.34)	(3.80)	(3.73)	(3.93)	(3.67)	(3.55)
Age $\geq$ 48 mos.	.003	.006	.006	-.017	-.017	-.017
	(0.33)	(0.59)	(0.59)	(1.08)	(1.07)	(1.02)
Age $\geq$ 54 mos.	.018	.016	.016	.029	.029	.028
	(1.61)	(1.47)	(1.46)	(1.58)	(1.61)	(1.54)
Male child	-.004	-.005	-.005	.004	.0005	.001
	(0.73)	(0.89)	(0.87)	(0.40)	(0.05)	(0.13)
Log mother's standardized height	.337	.360	.354	.026	.035	.025
	(3.58)	(3.82)	(3.74)	(0.17)	(0.23)	(0.16)
Mother's education $\geq$ 4 years	.014	.014	.007	.027	.032	.059
	(1.16)	(1.14)	(0.30)	(1.47)	(1.65)	(1.62)
Father's education $\geq$ years	-.001	-.002	-.002	.016	.018	.019
	(0.13)	(0.17)	(0.18)	(1.02)	(1.14)	(1.17)
Mothers age at birth	.0003	-.0001	.0001	.016	.019	.019
	(0.05)	(-0.03)	(0.04)	(1.83)	(2.15)	(2.13)
(Mother's age at birth -18)* Dummy = 1 if $\geq$18 years	.0005	.0008	.0005	-.017	-.020	-.020
	(0.10)	(0.15)	(0.08)	(1.85)	(2.19)	(2.17)
Land per adult (hectares)	-.002	-.001	-.001	.008	.009	.009
	(0.58)	(0.35)	(0.34)	(1.57)	(1.67)	(1.64)
% land in tree crops	.018	.012	.011	.002	.007	.003
	(1.92)	(1.11)	(1.09)	(0.16)	(0.40)	(0.17)
Community-level:						
Male agricultural wage (1000CFA)		.063	.062		.100	.089
		(2.24)	(2.18)		(2.20)	(1.94)
Distance to doctor (100km)		-.008	.009		-.018	-.017
		(0.47)	(0.47)		(0.56)	(0.56)
Distance to nurse (100m)		-.029	-.033		.039	.070
		(0.60)	(0.64)		(0.49)	(0.84)
Distance to primary school (100km)		-.670	-0.344		-.317	.547
		(1.06)	(0.49)		(0.31)	(0.48)

TABLE 4 (continued)

Variable	Height/Age[a] (1)	(2)	(3)	Weight/Height[a] (1)	(2)	(3)
Dummy = 1 if village has:						
Traditional healer		-.041	-.036		-.025	-.012
		(2.32)	(2.01)		(0.88)	(0.42)
Well without pump main water source		-.047	-.045		-.046	-.039
		(3.43)	(3.20)		(2.06)	(1.74)
Natural sources main water source		-.012	-.011		.008	.004
		(0.94)	(0.89)		(0.40)	(0.18)
Dummy = 1 if <u>Major community health problems</u>:						
Malaria		-.027	-.025		-.064	-.077
		(1.72)	(1.60)		(2.52)	(2.61)
Dysentery		-.036	-.036		-.008	-.009
		(2.55)	(2.51)		(0.35)	(0.41)
Measles, chicken pox		-.011	-.013		-.040	-.043
		(0.81)	(0.96)		(1.83)	(1.96)
Dummy = 1 if <u>Major community health service problems</u>:						
Absence of medicines		-.053	-.052		-.063	-.061
		(2.65)	(2.61)		(1.93)	(1.89)
Water or sanitary service problems		-.014	-.013		-.048	-.045
		(1.01)	(0.91)		(2.08)	(1.95)
Congestion problems		-.031	-.031		-.030	-.033
		(2.40)	(2.39)		(1.44)	(1.57)
<u>Interactions with mother education dummy</u>:						
Distance to doctor (100 km)		.026				-.044
		(0.36)				(0.37)
Distance to nurse (100km)		.054				-.117
		(0.42)				(0.56)
Distance to primary school (100km)			-.974			-3.665
			(0.76)			(1.75)
Constant	.001	.058	.049	-2.84	-.327	-.335
	(0.01)	(0.59)	(0.49)	(1.86)	(2.04)	(2.06)
R^2	.16	.22	.22	.17	.20	.20
F	7.38	5.14	4.66	7.51	4.47	4.17
Standard error	.062	.062	.063	.104	.104	.104
N	504	504	504	504	504	504

[a]/Log of standardized measurements using NCHS standards.

Table 5

Predictions of Log Standardized Measurements: East Forest and Savanna[a]

Predictions	Height		Weight for Height	
	East Forest	Savanna	East Forest	Savanna
Using All Own Characteristics	-.011	-.035	-.030	-.046
Exchanging Household Characteristics	-.018	-.028	-.043	-.033
Exchanging Community Characteristics	-.028	-.019	-.032	-.044

[a]From random effects specification wihtout interactions.

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