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Food Security and Health Security

Explaining the Levels of Nutrition in Pakistan

Harold Alderman
and
Marito Garcia

Nutrition depends on good health, including reduced infection, as well as on adequate food supplies. Giving mothers a primary education may be a more important factor in nutrition than raising household food intake.

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This paper — a product of the Agricultural Policies Division, Agriculture and Rural Development Department — is part of a larger effort in the department to study the impacts of food security policies. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Cicely Spooner, room N8-039, extension 30464. (February 1992, 48 pages.)

Most influential studies of malnutrition and public policy have focused on energy availability and consumption, tending to equate hunger with malnutrition. But recent studies have explored how other factors — notably infection and levels of maternal education — affect nutrition.

Alderman and Garcia's study of nutrition levels in Pakistan shows that raising household food consumption, for example, has less impact on nutritional levels than raising a mother's education does. They found that educating mothers to at least the primary level tends to reduce the level of child stunting (a long-term indicator of child nutrition) 16.5 percent, or roughly 10 times the impact achieved by increasing per capita income 10 percent. (The impact of education is not immediately realized; the diffusion of knowledge about good hygiene and child care associated with learning has a cumulative effect.)

Alderman and Garcia found that in Pakistan, food security alone is not enough to improve children's nutritional status. There may be welfare justifications for various food policies, but in rural Pakistan, especially, it is equally important to improve health and reduce infection.

Food Security and Health Security: Explaining the Levels of Nutrition in Pakistan

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Table of Contents

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FOOD SECURITY AND HEALTH SECURITY: EXPLAINING THE LEVELS OF NUTRITION IN PAKISTAN

INTRODUCTION

Many of the most influential studies of malnutrition and public policy have focused on energy availability and consumption.[1] That is, there has been a tendency to equate hunger with malnutrition. A number of recent studies by economists, however, have explored the relationship of factors other than food on the production of nutrition.[2] In this they are joining the ranks of clinical nutritionists who have recognized for some time that nutrition is determined by infection as well as by levels of food consumption (Scrimshaw, Taylor, and Gordon 1968; Mason et al. 1984).

The focus of this approach, then, is not on a single input — food security — but on the level of a number of inputs and the efficiency in which they are combined. Moreover, given that the manner by which households reduce infections or acquire health care often differs appreciably from the manner by which food is obtained, by viewing nutrition as an output in a production process, policy analysis can consider a broader set of interventions that may influence nutritional outcomes. Given that some inputs are public goods, the question can

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[1] For example, Reutlinger, Shlomo, and Marcelo Selowsky, Malnutrition and Poverty, Baltimore, MD, U.S.A.: Johns Hopkins University Press, 1976.

[2] See, for example, the review by Behrman (1991) and Schiff and Valdes (1990).

thus be phrased in terms of the responsiveness of malnutrition to current family resources, to lagged investments in human capital, and to community level investments.

The question is addressed, for example, by Thomas, Strauss, and Henriques (1991) whose inquiry on the role of maternal education on children's nutrition also investigates whether such effects are influenced by community services and infrastructure. Amongst their findings is the observation that a fair portion, but not all, of the impact of both education and income is explained by community covariates.[3] Community covariates which are generally found to influence nutrition in these and similar studies generally are reported in terms of physical health and sanitation infrastructure, although Strauss (1990) found that the quality of health services may be more important in explaining nutrition than the availability or distance of health care providers.

Such results documenting the importance of community infrastructure may go a long way in explaining why household income is often found to have a comparatively small impact on levels of malnutrition.[4] They may help explain, for example, why some countries have failed to improve nutritional indicators as rapidly as they have increased incomes. A case in point is Pakistan — the setting for the study reported below — where levels of malnutrition remain high (Malik and Malik 1991), despite

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[3] See also Thomas and Strauss (1990) and Barrera (1990).

[4] This is a generality; it is certainly not universally true (Alderman, forthcoming).

a GNP growth rate of 6.7 percent and despite reductions in poverty levels in all provinces (Malik 1991).[5]

This study uses a production function approach to ask whether the nutritional status of children in rural communities in Pakistan is responsive to changes in household food availability at the margin. Similarly, it evaluates the role of morbidity in explaining children's weights and heights. In doing so, it also evaluates the degree to which household income accounts for differences in observed nutritional status and the degree to which other factors such as education and public health contribute to the nutritional outcome.

MODEL AND ECONOMETRIC CONSIDERATIONS

The model employed here is based on the standard Beckerian model of household utility in which utility is derived both from purchased goods and home produced goods including health and nutrition. As the model is now well known (see, for example, Schultz [1984]), there are only a few features that need recapitulation for the current study. In particular, it is important to recall that the household must include both budget and household technology constraints in its optimization process. Thus, the derived demands for inputs into the production of household goods such as nutrition reflect both the marginal productivity of those inputs and the household's budget constraint. Assume that household utility is

[5] Anand and Kanbur (1990) report on a mirror image relationship, finding that expenditures on social programs had a greater effect on improving mortality in Sri Lanka than did investments aimed at raising income.

a function of consumption of n goods (G_n) and the health of its members (H_i), in particular of the children in the household.[6]

$$U = U(G_n, H_i) \tag{1}$$

There is a technology that produces child health that can be described in terms of j inputs which do not directly influence utility (Y_j) and at least one input which also contributes directly to the utility of the household (G_1).

$$H_i = \Gamma(Y_j, G_1, \mu_i) \tag{2}$$

Here μ_i denotes individual specific health endowments which are exogenous with respect to current inputs. Given exogenous income (I) as well as prices (P), which may be broadly defined to include time elements as well as cash outlay per unit of input acquired, one can define demand functions both for goods and inputs.

$$G, Y = f(I, P, \mu_i) \tag{3}$$

As depicted, neither prices or incomes directly enter into the health production function.

[6] The model follows that of Rosenzweig and Schultz (1983) and of Strauss (1990)

When undertaking empirical analysis, care must therefore be taken to distinguish demand functions from production functions; many so-called production functions are often hybrid combinations of the two. Such hybrids may provide insights if correctly interpreted — for example, if they are presented as conditional production functions — but they must confront the difficulties in distinguishing taste factors from the health production technology (Pollack and Wachter 1977).

In a similar vein, individual heterogeneity can cause biased results when studying the impact of household choices on the production of health or nutrition production. A common illustration of this possibility is the example of a family which feeds a sickly child infant formula instead of breast milk precisely because the child is less robust than its siblings and cohorts. A researcher unable to measure the genetic endowment of that child might estimate a biased coefficient of the effects of breast-feeding on growth (Habicht, DaVanzo, and Butz 1986).

Most simply, one can indicate the heterogeneity problem in terms of a violation of one of the assumptions underlying OLS regressions. When there is individual heterogeneity known to the household but not the researcher, one finds that the observed use of input will be correlated with the error in a model related health outcome to biological inputs of the form of equation (2). Since input use (Y_j) will increase or decrease according to individual attributes included in the error term μ_i, $COV(Y_j;\mu_i) \neq 0$.

One way to deal with the problem of heterogeneity is to estimate production functions and input demands as a simultaneous system. Rosenzweig and Schultz, for example, use Cobb-Douglas and translog production functions for birth weight in the United States with inputs as endogenous. Guilkey et al. (1989) use a similar model to examine the effect of prenatal care on birth outcomes in the Philippines.[7]

Frequently, however, it is difficult to find identifying restrictions for more than one or two simultaneously determined health care inputs. Even when such restrictions are plausible, the identifying instruments may have little explanatory power, leading to imprecise, although unbiased, estimates in the nutrition production function. Part of the difficulty is that a limited range of prices are often the only potential identifying instruments for variables such as health care utilization. For example, the availability of, or distance to, a health care facility is often found to determine health care choices (cf. Gertler and van der Gaag (1990) and the references therein). Unless, however, there are a number of distinct health service centers, such time prices only provide identification for a small number of instruments. Moreover, the quality of services may be a stronger determinant of health care utilization but, nevertheless, is often unobservable to the researcher. Finally, for many health care practices, community diffusion and interactions provide much of the

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[7] This study utilizes a rather extraordinary longitudinal data set which contains a great deal of data on household health care decisions as well as community infrastructure. See also Cebu Study Team (1989).

explanation for utilization. Complete utilization of such information, however, may require specialized modelling techniques (Bollinger 1990).

The study reported below circumvents these problems, to a degree, by modelling the <u>effects</u> of (largely unobserved) community factors and, subsequently, the role of such outcomes in the production of anthropometric measures of nutrition. The approach may be suited for a number of the integrated household data sets based on the methodologies of the Living Standards Measurement Study or the Social Dimensions of Adjustment in Sub-Saharan Africa project as well as a number of recent Demographic and Health Surveys. Each of these data sets, as well as our own, contain information from a number of clusters. One can utilize such information either using community fixed effects or community covariates (Strauss 1990; Thomas, Strauss, and Henriques 1991).

We begin by specifying the presumed error structure of the estimating equations for nutrition production and for input demand as follows:

$$H_{vi} = Y_{vi}\alpha + \omega_{Hv} + \mu_{Hvi} \tag{4}$$

$$Y_{vi} = X_{vi}\delta + Z_{v}\tau + \omega_{Yv} + \mu_{Yvi} \tag{5}$$

Here the v subscript denotes the village or community. The turn ω indicates unobservable community characteristics which influence health production and input demand. The terms X and Z denote vectors which contain observable household and community characteristics (including prices), respectively.

As mentioned, although conceptually the Z vector in equation (5) would contain the complete set of price and quality variables that influence input demand, often the vector contains only a few variables, with the unobserved component containing much of the information that explains input use. One approach to the estimation problem that this entails is to use a community fixed effect model. Such fixed effects models can be formulated in terms of deviations from village means. The general form of this model is:

$$Y_{iv} - \overline{Y}_v = (X_{iv} - \overline{X}_v)\delta + \mu i \qquad (6)$$

Since the variables in the Z vector are, by definition, fixed over the community there is no difference between the village values and the mean. They can, therefore, be dropped. Similarly, since the approach nets out the community specific error structure, one removes any bias introduced by its correlation with household characteristics.

This model can be equivalently expressed in terms of dummy variables:

$$Y_i = X_i\delta + K_v\gamma_v + \mu i \qquad (7)$$

where K_v denotes a vector of dummy variables which are defined as one if the individual is from the vth village, or cluster, and zero otherwise. When all cluster, or community, obser ations are collected during the same time period, then equation (7) is virtually equivalent to an equation with a seemingly more complete specification of exogenous price and infrastructure variables as in equation (5). Were ones objective to estimate δ then this would be a suitable approach.

However, the fixed effects approach reduces the possibility that the instruments can be identified in a simultaneous system along with a production function for nutrients. The Z vector is more likely to contain identifying instruments than the X vector of household characteristics. Looking at the issue from another perspective, since $\overline{Y}_v$ differs across villages due to structural reasons, there is more variation which is useful for estimating the impact in the second stage of the estimates in Y_i than in ($Y_{iv} - \overline{Y}_v$).

The approach used in this model attempts to occupy the middle ground between the fixed effects model and a model which specifies the complete Z vector. We include the cluster mean value of the left-hand side variable in equation (5) on the <u>right</u>-hand side of the estimating equation. This average implicitly contains information on prices and quality of infrastructure which is useful for identifying the impact of the variable which is being instrumented. In effect, we substitute $\overline{Y}_v = \overline{Z}_v \tau + \omega_{Y_v}$ into equation (5). While this approach does not provide a full understanding about how such prices and quality vectors affect the community average level of the input, it does allow one to understand how important such an input is in the production process. Indeed, the cluster mean could be a valid instrument in itself. Nevertheless, the structural equations used in this study also contain other information on the individual and household in addition to the cluster mean values.

There is one further consideration that needs be addressed. It is likely that ω_{Y_v} is correlated with ω_{H_v}. Consequently, although the approach will address the problem of individual heterogeneity discussed above, the community mean for Y will not necessarily result in an instrument that is free of a form of bias which stems from village heterogeneity. Note that this is not unique to the approach suggested; one need be equally concerned that K_v is correlated with ω_{H_v}. However, as long as $\overline{Y}_v$ is not perfectly collinear with K_v it will be possible to include the latter vector in the production function to handle the effects of community specific unobservables.

Model Specification

For the specific issue being investigated here, the production of nutrition status in children as measured by standardized weights and heights is considered to be a process which is influenced by two proximate factors: nutrient availability and (absence of) infection (WHO 1986). The relationship between diet and disease is symbiotic and complex, but is well recognized that both are essential for adequate growth, and may work in synergy (Martorell 1980). Household choices and individual characteristics moderate both the amount of exposure and the susceptibility to infection. These are influenced by community factors as well. Exposure to both diarrheal and other illness are strongly affected by the sanitation in the village and the diffusion of pathogens. The child's susceptibility is further influenced by feeding practices and whether or not the child has been vaccinated. The age of the child also affects susceptibility as does its health at birth, here proxied by the probability the child was born in a hospital, a correlate of prenatal care.

These considerations imply the following estimation equations which are referred to as Model I in the remainder of the paper.

Weight-for-Height = f(calories, diarrhea prevalence, other illness, hospital birth, vaccination, breast-feeding, household size, mother's education, mother's height, child's age, age squared, gender, district) (8)

Height-for-Age = g(calories, diarrhea prevalence, other illness, hospital birth, vaccination, breast-feeding, household size, mother's education, mother's height, child's age, age squared, gender, district) (9)

Models II and III below offer variations of this model to explore whether key results are sensitive to exclusion of redefinition of some of the variables. The rationale for these variants are discussed along with the results of the alternative models.

There are, then, five variables which appear in the nutrition production model for which community level infrastructure and interactions are presumed to be important: days a child is ill with diarrhea in the last two weeks, days the child has another illness in the last two weeks; whether a child has been vaccinated;[8] whether the child was breast-fed exclusively; and whether the child was born in a hospital. For each of these variables, community average values are included as instruments. In actuality, to avoid introducing a correlation of individual specific errors, each cluster mean that is used as an identifying instrument is the cluster mean value of Y exclusive of $Y_{i.}$ In addition, individual and household specific variables, such as own water supply and type of toilet, are included as instruments.

Strictly speaking, with the exception of breast-feeding, the five variables do not denote inputs into nutrition, but rather the outcome of investments in other aspects of health which influence the productivity of inputs into nutrition, or the investments themselves. They, nevertheless, are important for understanding the production of nutrition as measured by anthropometric indicators. Clearly an additional variable to explain nutritional status should be the child's food intake. This is not directly observed in this study and can only be proxied by family calorie availability[9] and augmented by variables for gender and age which may pick up any discrimination in nutritional

[8] To some degree, vaccination may be considered to have only an indirect influence mediated through non-diarrheal illness. However, most illness in the sample are upper respiratory or otherwise different from the illnesses for which vaccinations are available.

[9] This is a predicted variable as well. In this case, the estimations were undertaken using observed caloric purchases corrected for number of visitors present in the recall period.

investments. Note, however that government policy — particularly that which is aimed at guaranteeing food security — often is more able to influence the amount of food a household acquires than how it distributes it. Consequently, per capita household calorie availability can be considered as a measure of the expected impact of such policies on nutrition. Although family calorie availability is only one of the definitions of food security, it is addressed in this paper more explicitly since it remains as one of the central concerns of food and nutrition policy.

We would expect that the sign of the two variables for disease prevalence would be negative while those for hospital birth, vaccination, and breast-feeding, as well as calorie availability would be positive. Similarly, higher levels of mother's education is expected to lead to higher levels of nutrition. Our concern, however, is not so much in testing the signs as to indicate the order of magnitude impact on nutrition that feasible changes in the variables can be expected to have. Consequently, the study includes such projections in the discussion which follows the results.

Calories are generally assumed to be the limiting nutrient in diets of children where cereals are the main source of energy. Nevertheless, a number of other nutrients are also important. Since, however, there is relatively little price variation in the sample used for this study, a model similar to Pitt and Rosenzweig (1985) in which prices were used to identify the impact of nine nutrients on illness probability was precluded. As an alternative, income can be included in the nutrition production equation as a proxy for a range of inputs which a household may acquire using its family resources (Model IV below). As income is not an input per se, it may be argued that such a form of a nutrition production equation is more accurately a conditional production equation (Strauss 1990). Since, however, income is also included in the input demand equations, no causal pathway is obscured by its being included in this stage as well.

Income is also instrumented. Given that the concern is with children's nutrition this is less for the possibility of family heterogeneity (Senauer and Garcia 1991) or simultaneously, than with the conventional errors in variables bias towards zero. The measure for long run income was predicted expenditures per capita, using total dry and irrigated land holdings, land in tree crops, value of vehicles as well as livestock and other physical capital as identifying instruments. In addition, education and household composition are used to explain current household expenditures.

DATA

The model described earlier was applied to data from Pakistan, collected as part of a larger longitudinal study of rural households. The present study utilizes information from the first year (1986/87) of the three year survey.[10] The survey was conducted in the least

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[10] The nutrition literature discusses the use of growth velocity as a measure of nutrition as opposed to achieved levels (Beaton 1990). Use of the panel nature of the data could address issues of velocity and catch up, but would be a different study than that intended here.

developed districts from each of the four provinces in Pakistan. Following the methodology used by Pasha and Hasan (1982), one district was chosen from each province based on a variety of production and infrastructure indices. The selected districts were Attock in Punjab, Badin in Sind, Dir in NWFP, and Kalat in Baluchistan. In actuality, there are districts in Baluchistan which are somewhat less developed than Kalat, but the special logistic conditions ruled against fielding an intensive survey in those districts. While these districts were chosen on the basis of being underdeveloped, its is recognized that there are poor areas even within prosperous districts, hence Faisalabad was chosen as a fifth study site. Within each district, two markets, or mandis, were chosen at random. For each mandi, three lists of villages were constructed--those within 5 kilometers of the mandi, those within 10 kilometers, and those within 10 and 20 kilometers. A total of 52 villages were chosen randomly from these lists. The final sample comprised of 1,200 households randomly chosen from the complete list of families from these villages.

Anthropometric measurements of children below six years of age within these households were obtained from each of the six visits in the first year. For the present study, the analysis of nutritional status will use heights and weights obtained from 1,078 children in the third visit. The mean Z-scores by age groups were found not to differ significantly across the six rounds.[11] Variables used in the multivariate analysis are obtained from child and household level information from the third round. However, there are exceptions. Per capita expenditures (used as proxy for permanent income) are based on an annualized flow as obviously, a snapshot of the current expenditures in a particular round does not provide a complete picture of consumption patterns. Total expenditures is chosen as proxy for incomes as it is well known that incomes fluctuate more than expenditures particularly in an agricultural environment. A measure of predicted income is also a possible proxy for observed income, but that measure is also difficult to obtain when shocks are correlated across observations as is common in most agricultural communities.

More than half of the under six children in the sample areas are stunted (or chronically malnourished) as defined by the WHO reference standards for height-for-age. This is given in Table 1 with detailed prevalence rates for each district. Stunting is an indication of longer term problems related to cumulative undernourishment affecting the child's structural development. The sample average is higher than the stunting rate of 41.6 percent obtained by the Demographic and Health Survey of 1990 (DHS-IRD and Government of Pakistan). That survey, however, reports levels of nutrition for the entire country while the sample for the present study is based on rural districts with limited

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[11] Moreover, as expected, Z-scores are highly correlated between rounds. Unless one is modelling growth – a very different exercise than modelling status – little is gained by using all rounds of anthropometric data.

infrastructure. Kalat district had nearly double the level of chronic malnutrition than other districts. The area with the least amount of malnutrition is Faisalabad, which is the only area in the sample with reliable irrigated agriculture.

The other measure of malnutrition indicated in Table 1 is that of wasting (or weight-for-heights more than two standard deviations below the WHO reference standards). Approximately 5.8 percent of the children in the sample are wasted (or acutely malnourished). This rate is somewhat lower than the national data from the 1985 National Nutrition Survey or the 1990 DHS. Being a short-term indicator of malnutrition, wasting is subject to high fluctuations in any given population. Wasting is an indication of recent weight loss (or absence of gain) and is a condition of chronic semi-starvation resulting from a deficiency in calories. Badin have the highest proportion of wasted children with 8.7 percent (which is close to the national data) followed by Dir. Surprisingly, Kalat area has the least wasting although it has the most stunting. The two measures of malnutrition should be uncorrelated, although errors in the measurement of height could produce negative correlations. In this sample, th ecorrelation of -0.13 is not significant at any commonly used level.

The patterns by age groups (Table 2) shows dramatically increasing levels of wasting after 6 months of age. Stunting is also shown to increase as the children grow older. It has been hypothesized that such dramatic shifts in nutritional status in early childhood have been correlated with poor feeding practices. This situation usually occurs

Table 1--Nutritional status of preschool children (0-6 years) (N=1078)

	Mean Weight-for-Height (Percent of Standard)	Percent Below 80% Weight-for Height	Mean Height-for-Age (Percent of Standard)	Percent Below 90% Height-for-Age
Punjab				
Attock	93.8	5.9	91.6	60.2
Faisalabad	95.5	4.8	93.0	31.6
Sind				
Badin	95.8	8.7	89.2	59.5
NWFP				
Dir	97.9	6.2	90.9	44.3
Baluchistan				
Kalat	99.3	3.4	85.9	80.5
All areas	97.3	5.8	89.9	51.3

Source: IFPRI Rural Survey of Pakistan (Round 3), 1986/87.

Table 2--Nutritional status by age group (N=1,078)

Age Group	Percent below 80% weight-for-height	Percent below 90% height--for-age
Below 6 months	4.8	39.2
7-11 months	7.0	43.0
12-24 months	8.8	53.6
25-36 months	6.7	55.2
37-48 months	2.3	56.9
49-60 months	3.2	49.7

Source: IFPRI Rural Survey of Pakistan (Round 3), 1986/87.

Table 3--Simple correlation matrix: Villages averages of health and calorie measures

	Days Diarrhea	Days Ill	Birth at Hospital (1=yes)	Vaccination (1=yes)	Breast-fed (1=Exclusive)	Calories per capita
Days diarrhea	1.00					
Days ill	0.22	1.00				
Birth at hospital	0.01	0.02	1.00			
Vaccination	-0.04	-0.01	-0.03	1.00		
Breast-fed	-0.01	-0.01	0.05	0.15	1.00	
Calories per capital	0.02	0.05	-0.03	-0.04	-0.21	1.00

in a breast-fed child weaned gradually into starchy diet without high protein foods. Likewise, since chronic malnutrition is cumulative, stunting will likely be carried and increase over the latter years, particularly where catch-up growth is not perfect.

The correlation matrix of the cluster means values for various health measures, given in Table 3, indicates that there is a weak relationship between the various measures, or their main determinants. This confirms an underlying assumption of our analytic approach.

The observation is noteworthy inasmuch as roads, clinic proximity, and other physical infrastructure are plausible common determinants of most if not all of the measures. It is likely, then, that the structure of specific programs and the set of quality and diffusion variables are more important in explaining the measures, and further, that these programs differ for different village outcome variables. Health affects child nutrition as infection reduces the capacity for bodily absorption, as well as influences and changes in appetite and metabolism. Thus, sudden weight loss in children have been observed to be frequently related to continuous episodes of diarrhea. Morbidity was recalled for the past two weeks in each of the six visits in the first year. The availability of the panel information on morbidity allows us to use the data in two different ways. By averaging incidence over the six survey rounds, the morbidity variable in fact distinguishes longer term health effects from a more recent bout of diarrhea or illness. This information is the basis for the illness prevalence instrument. In addition, to capture recent health effects, the morbidity variable was constructed as a difference between the recent (third round) diarrhea or illness incidence and the average incidence over six survey rounds. The variable is further discussed below.

Morbidity among the sample children is high. Nearly 45 percent of the samples had either episodes of diarrhea or had some illness in the two weeks preceding the third visit. The survey indicates that 16 percent of children experienced diarrhea in the two weeks preceding the third visit, lasting 0.72 days on average (standard deviation of 2.03). Over the six visits, the average number of days with diarrhea per two-week period was 0.93 indicating that incidence in other rounds were higher. It maybe noted that the third round survey was conducted during the coolest season, after the monsoon rains. Illness other than diarrhea reported for these children averaged 1.38 days per two-week period, affecting 36 percent of all the children and is the basis for the illness variable used in the model.

Child feeding and weaning practices directly affect child nutrition (Habicht et al. 1976). Apart from the issue related to the effects of the duration and quantity of mother's milk, the problem is intertwined with the more general problem of hygiene and sanitary environment affecting the use of non-breast milk. This is particularly relevant where the availability of potable water in the village is not secure. Sixty five percent of the children were exclusively breast-fed, while infant formula feeding is not prevalent. From the age of six months, mothers generally start giving buffalo milk, usually diluted in equal amount of water to infants, as supplements to mother's milk. This practice has been associated to the higher prevalence of diarrhea and wasting among children in the 6-24 age months age bracket. This is likely due to the potential introduction of pathogens more than the possibility of over-dilution of the child's food supply. The rapid decline in weight for height in young children after six months of age has been observed in studies in many parts of Asia, Africa and Latin America (Teller and Zerfas 1990).

The average distance to the nearest government clinic is about half-an hour of travel time, indicating that availability of health services is relatively high in these poor areas. On average, private doctors are about an hour away from these households.

The means and standard deviations of the variables used in the analysis are given in Table 4.

RESULTS

While our main concern is with the regressions explaining nutritional indicators, it is useful to begin the discussion with the principal instrumenting equations. As mentioned above, these instrumenting equations address the concern that unobserved individual and village factors may bias results. They are, nevertheless, of interest in themselves. Each of these equations, reported in Table 5, were included in the simultaneous estimations of the nutritional status variables. All of the six instrumenting equations in the core model, including three zero-one variables (vaccination, birth at hospital and

Table 4--Variables used in the analysis: Means and standard deviations (N=1078)

Variables	Mean	S.D.
Z-score height-for-age	-2.52	1.60
Z-score weight-for-height	-0.38	1.22
Expenditures per capita per year (predicted rupees)	2494	891
Days diarrhea, past 2 weeks	0.93	1.25
Days ill, past 2 weeks	1.38	1.67
Birth in hospital (1=yes, 0=no)	0.05	0.23
Vaccination (1=yes, 0=no)	0.49	0.50
Breastfed exclusively (1=yes, 0=no)	0.65	0.47
Education of mother (1=primary and above 0=none)	0.07	0.26
Mother's height (cm)	151.98	6.00
Household size	10.55	5.02
Older sibling within 2 years	0.89	1.13
Younger sibling within 2 years	0.97	1.21
Age in months	35.56	19.04
Sex of child (1=male, 0=female)	0.51	0.50
Tapwater (1=yes, 0=no)	0.22	0.41
Price of wheat	2.29	0.25
Percent children below six years	0.25	0.11
Log calorie per capita (visitors excluded)	7.55	0.17
Price of wheat	2.29	0.25
Price of rice	2.11	0.12
Interaction household size x total expenditures	86.45	43.66
Distance to private doctor (minutes)	54.91	36.11
Distance to government clinic (minutes)	27.94	37.30

breast-feeding) were estimated as linear or log-linear models. This wasdone for ease of estimation of the simultaneous system model. Inserting the predicted values derived from the probit equations into the second stage regressions require the correction of the standard errors, otherwise the t-statistics would be biased. The correction procedure is computationally difficult in a multi-equation system with non-linear equations. In general, coefficients were similar when predicted probabilities from probit equations were substituted for linear estimates in the second stage equations.

Predicted total household expenditures has the expected sign in all equations in Table 5, although the significance is often low. Similarly, children of more educated mothers appear to have less disease and be more likely to be vaccinated. The interaction between community diarrhea prevalence and education of mothers is negative and significant. This implies that good hygienic practices by mothers with adequate individual knowledge will, to some extent, mitigate the negative effects from poor sanitary environment in these communities. Conversely, uneducated mothers have less skills to fend off the diseases of children due to exposure of her children to an unhealthy environment. In addition, having a clean and potable tap water supply[12] reduce the incidence of diarrhea and other illness. In all equations the average of the cluster values (exclusive of the individual in question) provides a significant amount of information for identifying the variables in

[12] This variable is taken as exogenous, although in the long run, it reflects household choice as well as community factors.

Table 5--Nutritional status determinants: First stage instrument equations for Model I (N=1078)

Independent Variables	Diarrhea Days	Illness Days	Birth in Hospital	Vaccination	Exclusive Breast-feeding	Log Calories per capita
Intercept	1.064 (4.23)**	1.168 (3.51)**	-0.026 (-0.69)	-0.084 (-1.09)	0.099 (1.22)	5.848 (37.38)**
Predicted expenditures	-0.158×10^{-4} (-0.32)	-0.162×10^{-3} (-2.48)**	0.148×10^{-4} (1.69)*	0.287×10^{-4} (1.73)*	-0.130×10^{-4} (-0.81)	
Age, in months	0.788×10^{-2} (1.01)	0.323×10^{-1} (3.07)**				
Age, squared	-0.301×10^{-3} (-2.81)**	-0.507×10^{-3} (-3.51)**				
Sex of child	0.541×10^{-1} (0.72)	0.155 (1.55)*		-0.286×10^{-2} (-0.11)	0.571 (2.32)**	
Mother's education	-0.229 (-1.75)*	-0.160 (-1.22)	0.151×10^{-2} (-0.06)	0.083 (1.68)*	0.097 (2.04)**	0.077 (5.62)**
Village prevalence of diarrhea x mothers education	0.293 (-2.35)**					
Household size	-0.013 (-1.68)*	-0.045 (-4.13)**	0.597×10^{-3} (0.42)	0.008 (3.04)**	-0.486×10^{-3} (-0.18)	-0.019 (-9.21)**
Village average excluding self	0.247 (3.12)**	0.943×10^{-3} (2.22)**	0.738 (9.36)**	0.849 (17.28)**	0.890 (17.86)**	
Tapwater	-0.137 (-1.53)	-0.098 (-15.26)**				
Distance to private doctor	-0.701×10^{-3} (-0.61)	-0.981×10^{-1} (-0.08)	-0.625×10^{-4} (-0.28)	0.131×10^{-3} (0.33)	-0.264×10^{-3} (-0.67)	
Distance to government clinic	-0.732×10^{-3} (-0.72)	-0.156×10^{-2} (-0.43)	0.321×10^{-4} (0.17)	-0.505×10^{-3} (-1.32)	-0.439×10^{-3} (-1.24)	
Log predicted expenditure per capita						0.340 (25.36)**
Log predicted expenditure x household size						-0.003 (-16.54)**
Price of wheat						-0.273 (-7.46)**
Price of rice						-0.247 (-7.13)**
Percent children below six years						-0.495 (-14.63)**

Note: Figures in parentheses are t-values.

* Significance at 10% level.
** Significance at 1% level.

[a] Predicted value

question. As mentioned above, this may reflect a combination of the proximity and quality of infrastructure as well as diffusion of community norms. Note, for example, that while income and education have some independent impacts on the probability that a child is vaccinated, the probability is largely explained by the community average. This presumably reflects availability of a program in the community. Similarly, community illness prevalence strongly affects the morbidity of a child regardless of household income.

None of the coefficient for distance to doctors or distance to government clinics are significant. These variables can be considered analogous to price and have been shown to be significant in equations explaining medical care for children in these villages (Gertler and Alderman 1990). Here, however, we are looking at preventative rather than curative services. The absence of explanatory power of the variables provides additional justification of our use of village mean prevalence as identifying instruments. These presumably capture effects of specific programs as well as quality of service delivery.

The second stage equations (Table 6) include dummy variables for four of the five districts. As discussed above, this reduces the possibility that the instruments for health will be correlated with unobserved community effects. It is an empirical question whether such dummy variables will be too collinear with the instruments to estimate their effects with precision. The results here, however, do not differ

Table 6--Nutritional status determinants: Second stage regression of alternative models (N=1078)

	Model I		Model II	
	Z-score, weight-for-height	Z-score, height-for-age	Z-score, weight-for-height	Z-score, height-for-age
Intercept	-0.076 (-0.03)	3.294 (1.05)	-0.211 (-0.08)	3.182 (1.01)
Log calories per capita[a]	-0.068 (-0.23)	-0.734 (-0.95)	-0.053 (-0.18)	-0.722 (-1.92)*
Diarrhea prevalence (days per 2 weeks)[a]	-0.047 (-1.64)*	-0.063 (-1.66)*	-0.050 (-1.85)*	-0.065 (-1.66)*
Ill prevalence (days per 2 weeks)[a]	-0.021 (-1.61)*	-0.001 (-1.65)*	-0.028 (-0.94)	-0.002 (-2.06)**
Recent diarrhea-average diarrhea			-0.023 (-1.63)*	-0.439×10^{-2} (-0.17)
Recent ill-days - average ill days			-0.007 (-0.62)	-0.723×10^{-3} (-1.84)*
Birth at hospital[a]	0.261 (1.68)*	0.081 (0.41)	0.259 (1.67)*	0.073 (0.38)
Vaccination[a]	0.065 (0.79)	0.059 (0.55)	0.061 (0.73)	0.017 (1.66)*
Breastfed exclusively[a]	0.201 (2.30)**	0.330 (2.94)**	0.202 (2.31)**	0.281 (2.52)**
Mother's education	0.067 (1.58)*	0.618 (3.43)**	0.065 (1.77)*	0.622 (3.45)**
Mother's height	0.004 (0.68)	0.005 (0.70)	0.004 (0.70)	0.006 (0.72)
Household size	-0.165 (-1.94)**	-0.021 (-1.91)**	-0.016 (-1.97)**	-0.019 (-1.81)*
Faisal	-0.105 (-0.81)	0.312 (1.86)	-0.102 (-0.77)	0.333 (1.96)**
Attock	-0.169 (-1.07)	-0.086 (-0.42)	-0.174 (-1.09)	-0.087 (-0.42)
Sind	-0.075 (-0.67)	-0.492 (-3.44)**	-0.081 (-0.72)	-0.497 (-3.47)**
Baluchistan	0.537 (4.17)**	-1.409 (-8.51)**	0.553 (4.26)**	-1.414 (-8.48)**
Age, in months	-0.041 (-5.34)**	-0.026 (-2.66)**	0.016 (-1.97)**	-0.026 (-2.68)**
Age, squared	0.004 (4.18)**	0.003 (2.58)**	-0.042 (-5.40)**	0.003 (2.64)**
Child sex	0.044 (0.62)	0.099 (-1.03)	0.043 (0.61)	0.099 (-1.08)

Note: Figures in parentheses are t-values.

* Significance at 10% level.
** Significance at 1% level.

[a] Predicted value.

appreciably either from versions with no district dummy variables or from versions with village dummy variables.[13] While our initial hypothesis was that predicted logarithm of calories consumed per household would have a positive coefficient in the second step of the analysis, this did not prove to be the case either in the production of long run nutritional status (height-for-age) or short run status (weight-for-height). This may be due to the insensitivity of this measure to intrafamily distribution or the need to consider other nutrients which may be complementary. Note, also, that calorie consumption may affect nutritional stature primarily at very low intakes and, therefore, the derivative may decline as calorie intakes rise. That is, over the range of intakes observed in our sample, additional household calories may have little impact, although they may have a significant impact at lower levels.[14] Furthermore, the calorie measure which is derived from quantities purchased, may also be only partially accurate as a measure of quantities consumed even at the household level. Finally, at the household as well as at the individual level, there should be a correlation of intakes and energy requirements, hence

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[13] These can be obtained from the authors. The latter alternative was not run as a simultaneous system but sequentially. The coefficients, then, would be unbiased although the standard errors would be biased. For this reason, we choose to report the model which includes district level dummy variables. To a large degree, however, the concern about biased coefficients is more theoretical than practical. The key results in the simultaneous estimates do not differ appreciable from the OLS results reported in the appendix. This, however, is not always the case in similar estimations.

[14] This differs from the issue at curvature of income-calorie relationship explored by Strauss and Thomas (1981), but it is analogous.

calorie consumption, even instrumented, may not precisely measure dietary adequacy.[15]

Both measures of illness, however, do influence the anthropometric measures of nutrition. The instrumented variables reported in Model I can be considered as predictors of the probability of illness or diarrhea. As this probability goes up, nutritional status deteriorates.

While this study does not explore the dynamic nature of nutrition, it is useful to make a foray into investigating the impact of a short term shock. To this end, two variables which indicate the deviation of a child's morbidity from that child's own pattern were constructed. These variables are the difference between the morbidity of the child in the period under investigation and the average for that child over the year.

$$D' = D_{it} - \bar{D}_i \quad \text{and} \quad I' = I_{it} - \bar{I}_i \qquad (4)$$

Where D' and I' are deviations from individual mean days with diarrhea and other illness respectively. Since $\bar{D}_i$ and $\bar{I}_i$ are removed, individual heterogeneity is controlled. This approach differs from an individual fixed effects model, however, in that we retain a number of instrumented variables which are considered time invariant including expected disease prevalence. This exploration, however, is simpler than

[15] On the latter two points, see Bouis and Haddad. On the general issue of calories as an input in the production of nutritional status, see Alderman, 1991, forthcoming.

the Hausman-Taylor model or its descendants (Hausman and Taylor 1981; Cornwell and Rupert 1988).[16]

Results from these explorations given in Model II indicate that recent diarrhea episode controlling for individual heterogeneity affects child weight-for-height while recent illness affects height-for-age. It maybe noted that these effects are separate from the average diarrhea incidence over the year. Clearly, the independent effects of being sickly over time versus the effects of recent illness and diarrhea should be distinguished for purposes of identifying measures to alleviate the nutrition problem. Sickly children are more predisposed to illness over time and therefore, preventative measures would need to be emphasized for such subgroups of children. Whereas, short term alleviating measures such as the use of ORS could be prescribed for diarrhea as they occur.

In both Models I and II, the impact of exclusive breast-feeding before the weaning age is strong and significant. These results underlie the critical role of mother's milk in the development of healthy children. The advantage of breast-feeding reflects the immunity transferred as well as the fact that bottle-feeding is used in an environment where water is not safe and therefore hygiene is an issue. Results also indicate than in these households there is a strong tendency for exclusive breast-feeding of infant boys more than infant

[16] The data do lend themselves to some of the methodological challenges that such models entail, but this remains beyond the present study.

girls. Due to problems associated with measurement of breast-feeding practices (Barrera 1991; Habicht, DaVanzo, and Butz 1986), however, a variant of the model that excludes the breast-feeding variable (Model III in Table 7) was tested. Few changes in the other included variables were observed indicating that the model is not sensitive to this alternative specification. Maternal education has a significant and positive effect on both long term and short term nutrition, as well as on the other inputs that enter into the production of nutrition. The impact of the education factor has also been found among rural households in the Philippines (Garcia 1991) and Sri Lanka (Senauer et al 1986). In those countries, maternal education were found to strongly affect food intake, and subsequently nutrition. Paternal effects were not studied, as the data coding only indicates the child's mother. Given the extended family structure, the data does not allow determining the corresponding spouse in all cases.

In addition to educational attainment, the role of the mothers's genetic endowments (mother's height) were modelled. Results indicate positive but not significant effects of the mother's height on weight and height of children. This lagged generational effect of maternal nutrition may dampen the impacts of current policies.

Child rearing and nutriture is also found to be affected significantly by the size of the household where the child resides. Parental care and attention which are particularly critical at the early stages of the child's development, are likely to be diffused in bigger households. The negative effects from a large household is reflected in the strong negative coefficient of household size variable on weight-

Table 7--Nutritional status determinants: Second stage regression of alternative models (N=1078)

	Model III		Model IV	
	Z-score, weight-for-height	Z-score, height-for-age	Z-score, weight-for-height	Z-score, height-for-age
Intercept	-0.071 (-0.01)	3.234 (1.03)	0.572 (-0.71)	3.684 (-0.86)
Predicted expenditures per capita			0.510×10^{-3} (1.60)*	0.605×10^{-3} (4.24)*
Predicted expenditures squared			-0.584×10^{-7} (-0.41)	-0.566×10^{-7} (-1.91)**
Log calories per capita[a]	-0.059 (-0.20)	-0.754 (-0.91)		
Diarrhea prevalence (days per two weeks)[a]	-0.050 (-1.67)*	-0.059 (-1.64)*	-0.041 (-1.74)*	-0.067 (-1.63)*
Ill-days prevalence (days per two weeks)[a]	-0.022 (-1.60)*	-0.003 (-1.62)*	-0.033 (-1.08)	-0.003 (-2.28)**
Birth at hospital[a]	0.256 (1.65)*	0.089 (0.44)	0.290 (1.49)	0.013 (0.05)
Vaccination[a]	0.062 (0.74)	0.052 (0.49)	0.027 (1.63)*	0.029 (0.13)
Breastfed exclusively[a] (1=yes, 0=no)			0.180 (1.62)*	0.297 (2.08)**
Mother's education	0.088 (1.63)*	0.584 (3.23)**	0.122 (1.75)*	0.443 (1.28)
Mother's height	0.004 (0.73)	0.005 (0.62)	0.003 (0.57)	0.005 (0.63)
Household size	-0.016 (-1.92)**	-0.206 (-1.87)*	-0.007 (-2.22)**	-0.052 (-1.95)**
Faisal	-0.169 (-1.33)	0.420 (2.56)**	-0.216 (-.58)	0.453 (0.95)
Attock	-0.327 (-2.31)**	0.178 (0.97)	-0.187 (-1.16)	-0.196 (-0.98)
Sind	-0.143 (-1.34)	-0.378 (-2.74)**	-0.197 (-0.54)	-0.380 (-0.82)
Baluchistan	0.520 (4.04)**	-1.383 (-8.34)**	0.267 (1.75)*	-0.855 (-0.76)
Age, in months	-0.042 (-5.47)**	-0.024 (-2.45)**	-0.043 (3.79)**	-0.023 (-1.95)**
Age, squared	0.454×10^{-3} (4.29)**	0.327×10^{-3} (2.40)**	-0.466×10^{-3} (3.79)**	0.307×10^{-3} (1.95)**
Child sex	0.058 (0.81)	-0.115 (-1.26)	0.053 (0.71)	0.102 (-1.06)

Note: Figures in parentheses are t-values.

* Significance at 10% level.
** Significance at 1% level.

[a] Predicted value

for-height and height-for-age in Tables 6 and 7. Since family time and resources are always scarce, the ability of parents to provide for any child may be affected by sibling competition.

The coefficients of age and its quadratic term indicate clearly that a child's growth path in these environments deviates from the norm as the child grows older and subsequently catches up. This confirms the decline in nutrition after the child is weaned particularly where proper child feeding is lacking, and where the health environment is poor. Contrary to findings elsewhere in South Asia, there seems to be no significant gender effects on nutritional status in the sample children. This result is also indicated in the data reported in the 1985-87 National Survey (National Institute of Health 1988).

One of the community health inputs that is likely to be important is that of vaccination. Results here, however, indicate that vaccination of the child does not have a significant effect on nutrition. Plausibly, the impact of vaccination is indirect via reduced illness although if the district dummy variables are not included in the production function the variable is significant in the equation for long-term growth. Birth at the hospital, which is strongly determined by income and proximity (as shown by the strong impact of cluster average) has a positive although slight impact on short term nutritional status. As it is more plausible for the variable to be a measure of prenatal care and therefore to explain long term nutritional status, the variable may proxy for other preventative health care.

Model IV presents a conditional production function which includes income as well as health inputs. It indicates a strong impact of income on the measure of long term nutritional status and a weaker effect in the short run. Although the coefficient is not the full effect of income (it also influences the level of inputs) its inclusion indirectly measures the effects of a variety of complementary inputs into nutrition which increase with income. Such inputs may include food quantity and quality, as well as health care decisions not otherwise modeled with the disease prevalence variables. The negative sign on the quadratic term for predicted expenditures indicates that the marginal demand for, or the marginal impact of, these inputs declines with higher incomes and usage, or both.

Few of the other coefficients change in magnitude in the conditional production function.[17] One may infer, then, that the educational level of mothers influence the efficiency of rearing children, which are effects quite different from a pure income effect. Many recent studies also found such strong influence of mother's education on child nutriture (Behrman and Wolfe 1984; Strauss 1990). The significance of the coefficient of maternal education declines in the height estimating equation when predicted expenditures is included not because female education has a strong impact on expenditures, but because it correlates, through assortative marriage, with household

[17] The vaccination variable appears positive and significant in the weight-for-height equation.

assets. Exclusion of the expenditure instrument, or the assets might give a biased impact of education per se.

CONCLUSIONS AND POLICY IMPLICATIONS

In recent debates about measures to alleviate the nutrition problem, two central questions have surfaced: (1) the relative magnitude of food and health dimensions of the malnutrition problem, and (2) use of own resource versus public investments in coping with the problem. Since the process of producing adequate nutrition is highly complex, any modeling that addresses such issues simultaneously is likely to be useful in identifying the key policy instruments that can be used.

In the rural environment of Pakistan, where 70 percent of the population live, our estimates suggest that child nutrition responds strongly at the margin to health inputs more than to food availability at the household level. Our results found an interdependence between morbidity and poor nutritional status. Modeled simultaneously, diarrhea reduces child weight-for-height and other illness curtail long run growth.

Since the incidence of diarrhea and illness are strongly affected by community covariates, a clear policy remedy is to improve community level investments to improve the sanitary environment. To address short term nutrition problems, an emphasis on income and price policies alone may be less effective than specific programs and investments at the community level. Community factors, however, do not necessarily have uniform impact and therefore, these needs to be explored much more closely.

In order to examine the magnitude of impacts from the various policy variables, a simulation based on the parameters of the Models I and IV estimated in this paper was conducted. The impact of each policy variable is estimated from the direct effects of that input into the production of child nutrition, as well as through its indirect effect on other inputs that also affect nutrition. For example, education affects child nutrition through its influence on the nutrition status production function. In addition, it is clear from the results that education also determines the level inputs such as birth in the hospital, vaccination and breast-feeding or the probability of infections.[18]

Although we explore such indirect pathways for a few potential changes, it should be noted that all such changes simultaneousl are not derived from adding the individual changes.[19]

The results given in Table 8 highlight the critical role of mother's education in achieving nutritional goals in rural areas. If mothers are educated to at least the primary level, the level of child stunting (a long term indicator of child nutrition) will be reduced by 16.5 percent or roughly one-fourth of the current prevalence levels.

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[18] Education often has an impact on monetary income, although in this rural population, female education at the primary level mainly influences non-pecuniary returns.

[19] The impact of two or more changes on the outcome variable can not be derived a priori. The total effect can be more or less than the sum, depending on the joint distribution of the policy variables in the community.

Table 8--Simulation of policy variables affecting malnutrition

Intervention	Child Wasting (Percent children below -2 ZWH)			Child Stunting (Percent children below -2 ZHA)		
	Current	Level with	Impact[a]	Current	Level	Impact[a]
Per capita expenditure (income)	8.9			63.6		
10% increase		7.4	-1.5 (16.1)		62.1	-1.6 (2.5)
Days with diarrhea, past weeks	8.9			63.6		
Reduced by one day		7.1	-1.8 (20.2)		60.1	-3.5 (5.5)
Reduced by two days		7.0	-1.9 (21.3)		54.2	-9.4 (14.7)
Days ill, past 2 weeks	8.9			63.6		
Reduced by one day		8.7	-0.2 (2.2)		62.1	-1.5 (2.4)
Reduced by two days		8.2	-0.7 (7.8)		60.6	-3.0 (4.7)
Mothers education	8.9			63.6		
Education to at least primary level		7.4	-1.5 (16.8)		47.1	-16.5 (25.9)
Household size	8.9			63.6		
Reduce by one person		6.8	-2.1 (23.5)		63.3	-0.3 (0.4)
Reduce by two persons		5.1	-3.8 (42.6)		62.4	-1.2 (1.8)

[a] Impact = Level of child wasting and stunting with intervention minus current level. Figures in parentheses represent percent reduction from current levels of wasting and stunting.

This is nearly ten times the overall impact achieved by, for example, increasing per capita income by 10 percent. The impact of primary education in the short term is somewhat smaller (a reduction of only 1.5 percent in child wasting) which illustrates that investments in education are not immediately realized, and that the diffusion of knowledge particularly of good hygiene and child care associated with learning have effects which are cumulative. Increasing per capita income by 10 percent reduces the incidence of child stunting by only 1.6 percent. This combines the indirect effects of income working through the effects on diarrhea, illness, vaccination, birth in a hospital, breast-feeding, and calorie intakes. It should be noted that direct income effects are not included in this calculation. Similarly, programs that decrease diarrhea occurrence by one day on average in any two-week period, reduces the incidence of child wasting by 1.8 percentage points (one-fifth reduction from current levels). The current rate of wasting is estimated at 8.9 percent. Reducing the days a child is ill by one day for any two-week period also reduces child stunting by 3.5 percent; 9.4 percent if illness is reduced by 2 days. This more than proportional improvement reflects the distribution of child heights in the sample rather than any increasing returns to scale.

The overall assessment from the morbidity related variables, therefore, clearly demonstrates the consequences from infection and the responsiveness of malnutrition to programs that prevent diarrhea and other illnesses among young children. Public sector programs on community health designed for curative purposes (e.g., clinics, ORS) and well as preventative (drainage, education campaigns, etc.) are important inputs for reducing morbidity in the rural areas.

In a similar vein, specific programs such as family planning have clear effects on reducing child stunting and wasting. Reducing household size by one person implies a reduction in the prevalence of child wasting by 2.1 percent (nearly one-fourth of the present prevalence levels, and 3.8 percent if by two persons. Smaller household size implies that more resources would be available per child.

While our results do not indicate what steps would be most cost effective at changing the community covariates which subsequently influence nutritional status, they do indicate the importance of community measures in conjunction with, or addition to, household resources. Education, one household asset that has a strong impact on nutrition, is generally achieved through public investment, even if enhanced by income growth. Public health programs which reduce disease or encourage prenatal care are also likely to influence the level of nutrition.

In conclusion, our results indicate that in Pakistan, food security alone is not sufficient in improving nutritional status, particularly of children. It is possible that at very low income levels, such as those prevailing in Sub-Saharan Africa, that the marginal impact of additional food calories could be large. However, the effect is likely to be nonlinear, declining with an increase of food availability.

While there are welfare justifications for various food policies that are distinct from nutritional concerns, health and infection are clearly shown in the rural areas of Pakistan to be more important factors in nutrition that need to be simultaneously addressed. This may not be the case in every community (see results in Bangladesh by Becker, Black, and Brown 1991) but the relative response of nutrition to food and to health should be considered as a major component in nutrition policy. This does not argue that decrease in food availability would not have consequences on the children in the community, but that, at the present levels, household food availability does not appear to be the most binding constraint on children's nutrition. Both food and health inputs are necessary for nutritional improvement.

Annex 1--Nutritional status determinants: OLS model (N=1078)

	OLS Model	
	Z-score, weight-for-height	Z-score, height-for-age
Intercept	0.69 (0.28)	2.587 (0.81)
Log calories per capita	-0.166 (-0.56)	-1.62 (-1.62)*
Diarrhea prevalence (days per 2 weeks)	-0.053 (-1.78)*	-0.062 (-1.62)*
Ill prevalence (days per 2 weeks)	-0.022 (-1.00)	-0.003 (-0.12)
Birth at hospital	0.212 (1.35)	0.070 (0.35)
Vaccination	-0.045 (-0.57)	0.012 (0.11)
Breastfed exclusively	(0.146) (1.68)*	0.293 (2.61)**
Mother's education	-0.044 (-0.27)	0.666 (3.14)**
Mother's height	0.004 (0.70)	0.005 (0.63)
Household size	-0.015 (-1.75)*	-0.021 (-1.93)**
Faisalabad	-0.095 (-0.71)	0.164 (0.94)
Attock	-0.177 (-1.33)	-0.164 (-0.81)
Badin	-0.080 (-0.76)	-0.543 (-3.85)**
Kalat	0.526 (4.03)**	-1.464 (-8.72)**
Age, in months	-0.041 (-5.29)**	-0.026 (-2.64)**
Age, squared	0.004 (4.11)**	0.003 (2.54)**
Child sex	0.046 (0.64)	-0.098 (-1.06)
F value	7.46	10.51
R^2	0.10	0.14

Note: Figures in parentheses are t-values.

* Significance at 10 percent level.
** Significance at 1 percent level.

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