The Determinants of Nutritional Status of Children in Rural India

Rekha Sharma, J.V. Meenakshi and Sanghamitra Das*

February, 2007

Preliminary Draft Please Do Not Quote

* *Rekha Sharma* is on the faculty of Sri Guru Gobind Singh College of Commerce, University of Delhi. *J.V. Meenakshi* is on the faculty of Delhi School of Economics, University of Delhi and currently she is visiting IFPRI. *Sanghamitra Das* is professor of economics at the Indian Statistical Institute, Delhi.

.

1. Introduction

The reduction of mortality among young children by two-thirds is one of the key objectives of the millennium development goals to be achieved by 2015 (United Nations, 2006). It is also endorsed by the Tenth Plan of Government of India. Childhood underweight is the significant contributor to mortality: it has been suggested that nearly half of deaths among children can be attributed to their being underweight (cited in de Onis et al, 2004). Further, according to the Comparative Risk Assessment Collaborating Group, underweight is the leading cause of ill health, with childhood and maternal underweight accounting for nearly 10 percent of the burden of ill health each year (Walgate, 2002).

Many of the world's underweight children live in South Asia, and studies suggest that they will continue to do so. Although the prevalence of malnutrition in South Asia is expected to decline, it will still remain "very high" (de Onil et al, 2004). This is true for India as well, where despite substantial improvements in the mortality rates and other indicators of human development, significant proportions of children are undernourished. More than half of children under the age of three years are underweight and 30% of newborns are significantly underweight (NFHS, 1998/99). A larger proportion of these children live in rural areas (49.6%) as compared to urban areas (38.4%) (NFHS, 1998/99).

It is this background that provides the context for this study, which examines the determinants of child nutritional status in rural India. This paper thus contributes to the limited empirical literature in this area in India, and attempts to discern the relative importance of individual, household and village level variables in determining positive nutritional outcomes. It builds on recent work that utilizes demographic and health surveys to answer similar questions in other contexts (see for example Girma and Genebo, 2002).

The analysis is based on unit record data on nearly 17,650 pre-school rural children in the 1998/99 National Family Health Survey (NFHS)[1]. While surveys on child anthropometric

[1] These data were downloaded from http://www.measuredhs.com

status have been conducted regularly by the National Institute of Nutrition, they are limited to ten states and are based on much smaller sample sizes.

The NFHS surveys are nationally representative and provide detailed information on anthropometric indicators for young children and their mothers. Additionally, they collect information on the frequency of certain food items consumed (but no information on food intakes per se), and other household and community level characteristics. The 1998/99 surveyed nearly 65,000 ever-married women, and included information on 18,000 pre-school children in rural India. Additional details on the survey are provided in Appendix 1.

The present study is based on the health production function framework, in which nutritional status is postulated as a function of nutrient intakes, socio-economic factors, which can be categorised into individual, parental, household and community level factors (see for instance, Behrman and Skoufias, 2004). This delineation helps demarcate those factors that are amenable to interventions through public investment – in the form of community sanitation works, for example, from those that require behaviour change communication – related to breastfeeding practices, for example.

In contrast to much of the available literature which have used instrument variable approach to predict income and fixed effect estimation to control for unobserved heterogeneity, we use the reduced form to estimate the effects of various factors on child's weight and use a multi-level fixed effects model to control for unobserved characteristics of the mother, the household and the village of residence.

The rest of the paper is organized as follows. Section 2 introduces the model and variables used. Section 3 provides some summary statistics while section 4 discusses the results of the estimation. Section 5 outlines the principal conclusions and draws implications for policy.

2. The Framework and Model Specification

The model of nutritional status is derived from household production function framework used in several studies - for example by Behrman and Skoufias (2004), Smith and Haddad (2000), Strauss and Thomas (1995), Alderman (1990), Sahn (1990), among others. The household maximizes the household multi-member utility function of its 'n' members consisting of adults and children: W (U_1, U_2,…….U_n) …… …… ……. (1)

And utility function takes the form

$$U_i = U\left(NS_i, X_f^i, X_{nf}^i, L_i\right) \qquad \text{i= 1,2,3…….n} \quad U' > 0,\ U'' < 0 \ldots\ldots\ldots\ldots (2)$$

where n is the number of members , NS is the nutritional status, X_f is food expenditure , X_{nf} and L are non-food expenditures and leisure time of i^{th} household member.

The maximization of (1) subject to the household budget constraint, time constraint and 'technology' determining nutritional status (NS) is given by

$$NS_i = f(X_f^i, X_{nf}^i, C^i; X_i, X_h, X_V)$$

where X_f food expenditure, X_{nf} is non-food commodities and services purchased for caregiving purposes , C^i is care received by the i^{th} child respectively and X_i is set of exogenous child-specific variables like age, gender, age of mother at birth) , X_h is set of household-specific variables (wealth, sanitation, etc) and X_V is set of village-specific variables like availability of health facility, drainage system, aganwadi in village.

gives the following reduced form for the i^{th} child:

$$NS_i = f(X_i, X_h, X_V, P, W, \mu)$$

where P is a vector of prices[2] of X_f, X_{nf} and W is the household's wealth[3]; μ (μ_i, μ_h, μ_v) unobserved factors that affect nutritional status, which may be possibly correlated with $X_{i,,}$

[2] The NFHS does not collect any information on village-level prices and hence ignore its impact. We assume that it is not correlated with the included village variables.

[3] The reduced form estimates can include asset stock. This approach is used here and thus does not suffer from the problem of simultaneity.

X_h ,X_v. For instance, genetic endowment specific to a child that is not captured by his/her mother's BMI and age at birth.

Some of the studies in the literature have used fixed effects specification to control for unobserved heterogeneity and use instrument variable approach to predict income (Attanasio, 2004;Olaniyan, 2002; Alderman, 1990 etc). In this study, we use fixed-effects at the various levels - district, village and mother to account for any unobserved heterogeneity and step-wise estimate the impact of the village, household and child–specific explanatory variables on weight of the child as discussed in detail in Appendix 2.

2.1 Nutritional Status

The nutritional status can be measured by different variables related to weight and height of the body. In this study, we represent nutritional status (NS_i) as the standardised weight [4] defined as:

$$NS_i = \frac{W_i - \mu_i}{\sigma_i},$$

where W_i is the observed weight of the child, μ_i is the reference median weight of a child of a particular gender and age and σ_i is the standard deviation of the particular gender and age of the reference population of NCHS/WHO.

2.2. The Explanatory, or Health Input, Variables

Child-specific variables

Child's nutritional status is related to age, as it is sensitive to factors such as nature and period of feeding/weaning practices, care, and exposure to infection, especially when exclusive breastfeeding stops around 4-6 months of age. Typically, for children under 3 years of age, duration of breastfeeding and introduction of complementary foods should be introduced are the most important determinants of the health outcome. Therefore, in this

[4] This is a representative measure (over other measures such as stunting and wasting) as it represents both short term and chronic undernourishment. Further, it is believed to be measured with greater precision—accurate determination of child height can be difficult as it requires proper position / posture of the body that may be more difficult to ensure for children under 3.

study, we have introduced four age group dummy variables consisting of – 0-6 months, 7-12 months, 13-24 months and 25-35 months to capture age-specific effects. Maxwell et al (2000), Yimer (2000) etc have also observed non-linear relationship u-shaped relationship between age and nutritional status.

The WHO and UNICEF recommend that infants should be given only breast milk for about first six months of their life. By the age of seven months, adequate and appropriate complementary food should be added to get the sufficient nutrients for ideal growth. It is further recommended that breastfeeding should continue along with complementary foods through the second year of life. However, delayed breastfeeding or very long period of breastfeeding may adversely affect the health outcome as evident in Behrman (1982) and Martorell et al (1984). Therefore, to capture that effect we introduce interaction between age groups and current breastfeeding status.

As the NFHS data only provides information on frequency of complementary food intakes such as green leafy vegetables, fruits, mushy food, other milk, we specify the following dummy variables - 'daily', 'sometimes' or never - of consumption of green leafy vegetables / fruits, other milk and mushy food. These dummy variables are interacted with the age groups to capture the effect of difference in the feeding practices and complementary food on nutritional status.

Birth order is introduced to test as is usually hypothesized that a high birth order[5] is associated with poor nutritional status of young children as it increases the competition for the resources and maternal care within the family (Maxwell et al, 2000). Whether female children have nutritional disadvantage as compared to their male counterparts is tested through introduction of male dummy variable. Further, an interactive dummy between gender and birth order has been constructed to examine whether there are gender-specific effects as found by Behrman (1988b), Haddad (1987), and Horton (1986).

Age of the mother is used as a proxy for her care taking abilities. It is contended that mothers who are too young may not be experienced or mature enough to take care of young

[5] Here, it does not represent half siblings – children living in the same household but having different mothers and same relationship to head of the household.

children (Mishra et al, 1999) and that therefore, children born to younger mothers have a higher risk of being malnourished. In estimation, to test for any non-linearity, following Maxwell et al (2000), the square of the age of the mother have also been included.

The ability of the child to absorb and utilize nutrients depends on his or her health (see for example (Martorell and Habicht, 1986)) To account for this, we use information on whether the child suffered from fever or diarrhoea in the past two weeks preceeding the survey. Ill health of a child can contribute to poor nutritional status on account of loss of appetite or greater waste (Svedberg, 2002; Martorell et al, 1980; Waterlow and Tomkins, 1992).

Household-specific variables

Nutritional status of the mother is an extremely crucial factor as it operates right from the birth of the child. Malnourishment in woman would cause easy fatigue and may affect women's cognitive performance and therefore, her ability to adequately take care of child (Beard, 2001). It also means mother might be less capable of breast-feeding successfully (Engle et al (1999) and Ramalingaswami et al (1996)). In this study, we consider body mass index (BMI)[6] as indicator of nutritional status of the mother .We also introduce square of BMI to observe if there is any non-linear pattern because both BMI less than 18.5 and equal to or more than 30 are desirable as these indicate unhealthy life.

Besides biological factor, the degree to which the mother has autonomous decision-making power is another factor that influences child nutritional status. Smith et al (2003) and Thomas (1997) argue that women with low status tend to have weaker control over household resources, tighter time constraints, less access to information and health services, poorer mental health, and lower self-esteem which affect the kind of care which they get and give to their children and thereby adversely affect the nutritional status of their children. In this paper, a woman's autonomy is represented through a dummy variable which takes a value 1 if

[6] Micozzi et al (1986) have shown that BMI is better indicator of anthropometric failure than height or weight individually. Therefore, we choose BMI as an indicator of nutritional status of adults instead of any other measure. BMI less than 18.5 indicates high prevalence of nutritional deficiency while equal to or greater than 30 indicates obesity.

mother takes decisions involving her healthcare on her own or jointly with her husband and zero otherwise.

Some studies have found that education of the parents, particularly mother, is associated with better provision of caregiving resources and improving childcare practices (Horton, 1988; Haddad, 1997; McGuire and Popkin, 1989). However, Sahn (1990) does not find the same and argues that a little variation in education levels or attending few years of school in the distant past may not make much difference to current functional abilities of the mother and thus may not help in improving the nutritional status of the children significantly. We use a set of four dummy variables to capture the effect of different levels of mother's educational achievement- illiterate, less than middle, middle, and high school & above education with illiterate mothers as the control group.

We also include same education variables to represent the educational status of the father though the result for this are inconclusive in the literature. For example, Sahn (1990) and Alderman (1990) find that mothers are more inclined to allocate scarce household resources in favour of children than their husbands (fathers). Thus, this bias in preferences translated into a negative effect of the father's education on nutritional status of children in their study. Maitra et al (2006) showed that educational attainment of parents did not have statistically significant effect on the health status of the children.

The size and composition of a household may affect the level of care received by young children and thus have a bearing on their nutritional status. The evidence on the effect of household size is mixed. Sahn(1990), Behrman and Wolfe(1984) find larger household have children with better nutritional status as a consequence of economies of scale. Sahn (1990) found that greater the number of young children in any given householdsize, the greater would be value of per adult equivalent expenditure units. This would imply greater availability of food and non-food goods per child and may contribute to better nutritional status. While Melville et al, (1988) and Maxwell et al (2000) find the reverse situation implying that younger siblings (less than 5 years) compete for nuturing time and maternal care and thus adversely affect the nutritional status. However, older siblings (six years and above) do not directly compete for nurturing time with younger child and provide some child-care assistance which results in better nutritional status of the young child. To examine how

these factors influence rural Indian children, we include the percentage of children in the age groups 0-5 years and 6-15 years, as well as the percentage of adult women and men in the household.

Another important household resource is household income which is often represented by percapita expenditure. NFHS does not provide any information on income, therefore, we use assets as proxies for household income (see for example Strauss (1990), Victora et al (1985), Horton (1986), Desai et al (1970)). The wealth indicators explored are size of the land holding, and dummy variables for representing a household that owns livestock, has provision of electricity in the house and has a kutcha house instead of pucca/semi-pucca house.

Ethnicity and religion are two important social factors that influence the caring practices or habits of the household. Ethnicity is represented by a dummy variable which takes a value 1 if household belongs to SC/ST/OBC category and 0 otherwise. Similarly, religion is represented by dummy variable taking a value 1 if the household follows Hinduism and 0 otherwise.

The effect of unhygienic environment (water and sanitation) on morbidity and mortality through infections is well established in the literature (Checkley et al, 2004; Esrey, 1996; Esrey et al, 1992). Poor sanitation and water facility, poor personal hygienic and environmental conditions are important causes of infection resulting in a greater risk of illness and thus, malnourishment. In this work, we include provision of sanitary facilities as denoted by a dummy variable representing that household which does not have its own toilet.

To capture the relative importance of source of water, we include dummy variable that reflects the open source of water like well, rain water, pond etc. as against covered source, pipe and pump water[7], used by the household. Jalan and Ravallion (2001) found positive health gains for children under the age of 5 years from piped water in rural India. Similarly, to examine, whether households that purify water have better nourished children, we include a dummy variable which takes a value 1 if household is not purifying water and 0 otherwise.

[7] It includes covered wells.

Village-specific variables

Among the village-specific variables, we have considered exogenous variables like access to healthcare infrastructure[8], existence of aganwadi[9] which reflect provision of infrastructure facilities in the village. Recent studies by Thomas et al (1996), Lavy et al (1996) show that increasing provision of basic health services such as birth services, availability of drugs, immunization, improves the nutritional status of the children considerably. Also, community health environment is represented a dummy variable which takes a value 1 if there does not exist a drainage facility in the village.

3. Some Summary Statistics.

Table 1 provides summary data on the various variables used in estimation. Since most of these are dummy variables, their means simply reflect the percentage of observations with the value 1.

Almost half of the children under 3 years of age are underweight. If one looks at their feeding pattern, nearly three-fourth of the pre-school children are still breastfed but at the same time almost 36% of children who are more than one year old never received any solid complementary food. Nineteen percent of the children under age three suffered from diarrhoea and thirty percent suffered from fever during preceding two weeks before the survey.

Observing the caring abilities, one finds around 42% of the mothers are undernourished as these have body mass index less than the desired 18.5 kg/m^2 and 56% do not enjoy any autonomy in health decision-making in the house.

Further, the extent of illiteracy among parents is quite substantial as almost two-thirds of children have their mothers and one-third of their fathers as illiterate. As far as religious practices are concerned, around eighty-two percent of the households follow Hinduism. Two-

[8]It includes primary health centre, sub-centre, dispensary and hospital.
[9] The data here indicates only the availability and not actual utilization of the services.

third of households belong to scheduled tribe, scheduled caste or other backward class. Mean household size of households is 7.7.

The condition of sanitation facilities is extremely poor as large percentage (83%) of the households do not have any toilet facility and almost half of the villages do not have drainage facility.

Around seventy percent of the households drink water from covered sources of water-pump and pipe and rest from open sources like well, pond, river, surface water. The practice of purifying water is not widely adopted as only one-fourth of population uses some method of purifying water.

Types of house, size of the land holding, electricity connection are the indicators of standard of living, which exhibit wide variation. Only 18% of the households live in pucca houses made up of high quality material while 40% live in semi-pucca houses and 42% live in kuccha. Almost half of houses do not have electricity connection. Infrastructure facilities in terms of health facility exist only in 56% of the villages while only a quarter of villages have aganwadi .

4. Results

4.1. The role of child-specific variables

Table 2 indicates children between age of 0-6 and 7-12 months have better nutritional status than children between 13-24 and 25-35 months of age. It is in line with the fact that it is this period when weaning starts and children are greatly exposed to infection and disease. The descriptives also show that the percentage of children between 6-11months of age who are undernourished in rural India is 40 % and increases to 61% for children between 12-23 months of age (NFHS, 1999/2000). It has also been observed in the other studies examining the relationship between age and nutritional status (For example, Maxwell et al (2000), Yimer (2000), Marotrell et al (1995)).

Feeding practices related to breastfeeding and quality of complementary food significantly influence the weight of the child in the family. The importance of exclusive

breastfeeding upto six months of age is reflected from the negative significant coefficient of interactive dummy of child in the age group 0-6 months who is being fed other milk daily. In other words, child up to six months of age if is fed other milk daily would have poor nutritional status as compared to one who is never fed other milk.

Children who are breastfed in the older age group especially, beyond the age of two years have poor nutritional status as compared to other children as also evident in Behrman (1982) and Martorell et al (1984). It may simply reflect these children are simply latching on to breast for a long time without drawing any benefit of breastmilk in terms of nutrition or immunity which is there in early breastfeeding.[10].

The weight of the child in the age group of 13-24 months improves if he is introduced to complementary food i.e. mushy food daily. This highlights the importance of complementary food in terms of basic nutrients when children grow older.

Gender of the child does not affect the nutritional status of the child. Birth order of the child turns out to be negatively associated with nutritional status of the child. This reinforces the fact that the children in earlier sibling order are advantaged relative to their brothers and sisters born later. This is expected as the birth-order rank increases, the child has to compete for maternal care and resources with the siblings and that adversely affects his health outcome as is also evident from the work of Horton (1988) and Behrman and Wolfe and (1987)[11].

As expected, the occurrence of diarrhoea or fever has deleterious impact on weight of the child emphasizing the importance of disease in etiology of malnutrition. It also suggests good hygienic habits need to be inculcated among the household members as infection is the most common cause of diarrhoea and fever among children.

The coefficient of age of the mother is positively significant indicating that with increase in age mothers become more experienced or mature and their ability to meet the caring needs of children increases and thus, improves weight for age scores.

[10] A large proportion of these children belong to low and medium socio-economic group than high-income group reflecting their inability to provide adequate meals.

[11] Only 4% of the households who have high standard of living have birth order of five as compared to 54% of the households having low standard of living. High birth order children are disproportionately from lower socio-economic strata, which are already hard pressed for resources

4.2 The role of household-specific variables

Table 3 indicates a non-linear inverted u-shaped relationship between BMI of mother and weight of the child as also evident in studies by Engle et al, (1999) and Martorell et al, (1998). The estimates show that mothers' having BMI more than 31kg/m^2 have adverse effect on the nutritional status of children. This result is in line with the fact mothers having BMI equal to or more than 30kg/m^2 BMI are considered as obese or unhealthy mothers.

After controlling for household economic status, parental education has a non-linear positive significant effect on weight. For positive impact on weight, mother needs to have passed at least middle school but father only needs primary schooling as the minimum requirement. However, after the first impact, the weight effect does not increase monotonically with parent's education.

The dummy variable for SC/ST/OBC households is negative and significant, indicating that such children weigh less than their non-SC/ST counterpart. However, there are no significant differences in the z scores of children of the Hindu and non-Hindu family.

Household size and its composition turn out to be significant determinant of child's nutritional status in rural India. Larger households have nutritionally better off children than smaller sized households, perhaps, on account of economies of scale. This result may also be seen in the study of Behrman and Wolfe (1984).

Given the fact that increase in children would mean some competition for child care and attention, positive coefficient of both younger and older children (above 5 years) in the household[12] may seem counter-intuitive. But the plausible explanation may be that increase in percentage of children in comparison to adult male for a given household may imply increase in value of expenditures in per adult equivalent units which would enhance the nutritional status; as also found in Sahn (1990) or perhaps they feel more happier with more children, which may lead to better absorption of food. Similarly, fewer females probably imply more resources are freed from consumption.

All the variables associated with standard of living or wealth status are significant in determining the nutritional status of the children, as expected (Strauss, 1990; Horton, 1986).

[12] Here, it represent half siblings as well as full siblings.

For instance, the coefficients associated with owning livestock and size of the landholding are positively significant. The impact on weight is greater for housing and amenities. Children living in pucca or semi-pucca houses have higher nutritional status than those living in kutcha houses (Olaniyan, 2002).

Open sources of drinking water and its purification do not turn to be significant in determining the nutritional status of children under three of age as our specification conditions on current health of the child in terms of diarrhoea and fever which easily result from contaminated water[13].

The provision of healthy environment plays crucial role in determining the nutritional status of the children as also found in studies of Esrey et al (1992) and McJunkin (1982). The lack of toilet facility implies increased probability of infection and thus adversely affects weight of children under age 3 in the rural areas.

4.3. The role of village-specific variables

Table 4 indicates no drainage or drainage has no significant effect on the weight of the child as only 1.8% of the households have underground drainage. Existence of any health facility[14] and aganwadi within the village are also not significant.

All the considered village level variables are insignificant implies that none of these implemented policies for improving health of the rural children have been effective – suggesting low quality (no doctors) and insufficient availability of services[15].

5. Conclusions and Implications

This paper examined the determinants of nutritional status of pre-school children in rural India. Nutritional status starts deteriorating after infancy, the age when child is weaning and exposed to infection. It underscores the role of care in terms of breastfeeding and timing of complementary food in improving weight of preschool children. Breastfeeding beyond infancy is not encouraged while what becomes important is introduction of mushy food regularly after attaining one year of age. Higher birth order implies all the more competition

[13] Even when only piped water was used as a covered source of water , it did not turn to be significant.
[14]It includes primary health centre, sub-centre, dispensary and hospital.
[15] Aganwadi exist only a quarter of villages only.

for receiving maternal care and thus, increasing birth order deteriorates the nutritional status of child. Weight loss due to occurrence of diarrhoea or illness stresses the importance of good hygienic behaviour of child as well as the members of the household.

These results reinforce the need for family planning along with emphasis on spreading awareness of breastfeeding, supplementary diet and good hygiene for the pre-school children for improving their weight. Families need to be educated about appropriate feeding practices for infants and young children.

Nutritional status, age and education of mother which are proxy for caring abilities are significant determinants of nutritional status of children. It advocates that well-nourished, educated and experienced mothers produce better-nourished children. One should discourage too young women to become mothers. Thus, one needs to design policies which give special attention to improve the status of the prime caretaker, mother.

Availability of sanitation and housing facilities are the key factors that comprise the living environment for a household. It stresses the importance of hygienic conditions that reduce the risk and spread of infections, as infections are a prime cause of ill health among children. It emphasizes the need for sanitation facilities at the household level.

Household resources represented by livestock, size of land holding and household size also positively determine the nutritional status of the child.

Current policies at village level such as health facilities and aganwadi already in place need to be reviewed to make them meet their goals. Clearly, there is no single solution to the problem of malnutrition; what is required is a set of complementary strategies.

Table 1: Means* and standard deviation of the variables related to children under age 3 years and their households

Variable	Abbreviation	Mean	Std. Dev.
Underweight children	Underweight	0.49	0.49
Child between 0-6 months of age	child06m	0.208	0.406
Child between 7-12 months of age	child712m	0.162	0.368
Child between 13-24 months of age	child1324m	0.332	0.471
Child between 25-35 months of age	child2535m	0.298	0.457
Mother's age at birth (in years)	momage	23.5	5.3
Gender of child (male=1)	malechild	0.524	0.500
Birth order (1,2,3..)	bord	2.85	1.89
Incidence of diarrhoea or fever	diarfever	0.396	0.489
Currently breastfed	currentbreastfed	0.781	0.414
Never given green leafy vegetables or fruit	Glvfrtnever	0.363	0.481
Never given mushy food	Mushynever	0.313	0.464
Never given other milk	othmilknever	0.414	0.493
Woman takes health decision	womanpower	0.445	0.497
Body mass index (kg/m^2)	bmi	19.186	2.532
Mother's education: Illiterate	illitmot	0.626	.484
Less than middle school	ltmidmot	0.188	0.391
Middle	midmot	0.086	0.280
Equal to high school or above	highmot	0.100	0.299
Father's education: Illiterate	illitfat	0.337	0.472
Less than middle school	ltmidfat	0.255	0.436
Middle	midfat	0.143	0.350
Equal to high school or above	highfat	0.266	0.442
SC/ST /OBCHouseholds	scst	0.661	0.473
Hindu	hindu	0.822	0.382
Has electricity	electrichouse	0.489	0.500
Household size	hhsize	7.720	3.918
Percentage of children between: 0 to 5 years	perchild05	29.738	11.981
6 to 14 years	perchild614	14.946	14.951
Percentage of females equal to or above 15 years	perafe	28.955	10.039
Percentage of males equal to or above 15 years	perama	26.361	10.467
Owns a kutcha house	kutcha	0.421	0.494
Open sources of water (well, pond, river etc.)	openwater	0.281	0.450
Not purifying water	notpurify	0.755	0.430
No toilet	notoilet	0.827	0.378
Owns livestock	ownlivestock	0.639	0.480
Size of land (in acres)	sizeland	3.314	10.821
No drainage system in the village	nodrainage	0.526	0.499
Existence of aganwadi	aganwadi	0.263	0.440
Health facility within the village	hfvillage	0.565	0.496

- Thses are weighted means
- Source: Calculated from unit record data of the NFHS-II (rural) (1998/99)
-

Table 2: Robust estimates of Weight for age Z score (Mother-level fixed effect)

Variables	Abbreviation	Coefficient	t-value
Child-specific factors			
Child between 7-12 months of age	child712m	-0.705	-1.33
Child between 13-24 months of age	child1324m	**-1.328**	-2.82
Child between 25-35 months of age	child2535m	**-1.306**	-2.84
Child between 0-6 m* currentbreastfed	Child06breastfed	0.507	1.32
Child between 7-12 m* currentbreastfed	child712breastfed	0.279	0.83
Child between 13-24 m* currentbreastfed	child1324breastfed	**-0.275**	-1.64
Child between 25-35m * currentbreastfed	child2535breastfed	**-0.487**	-2.01
Child between 0-6 m*glv daily	child06glvdaily	-0.502	-1.01
Child between 7-12m* glv daily	child712glvdaily	-0.018	-0.09
Child between 13-24 *glv daily	child1324glvdaily	-0.104	-0.48
Child between 25-35 *glv daily	child2535glvdaily	0.089	0.46
Child between 0- 6*glv sometimes	child06glvsometimes	-0.153	-0.86
Child between 7-12 *glv sometimes	child712glvsometimes	0.074	0.44
Child between 13-24* glv sometimes	child1324glvsometimes	-0.178	-0.90
Child between 25-35* glv sometimes	child2535glvsometimes	0.005	0.02
Child between 0-6* other milk daily	child06othmilkdaily	**-0.278**	-2.17
Child between 7-12 *other milk daily	child712othmilkdaily	-0.167	-1.05
Child between13-24*other milk daily	child1324othmilkdaily	0.105	0.66
Child between 25-35 months of age* other milk daily	child2535othmilkdaily	-0.063	-0.62
Child between 0-6* other milk sometimes	child06 othmilksometimes	-0.057	-0.31
Child between 7-12* other milk sometimes	child712mothmilksometimes	-0.004	-0.02
Child between13-24*other milk sometimes	child1324m othmilkdaily	-0.002	-0.01
Child between25-35*other milk sometimes	child2535m othmilkdaily	0.074	0.65
Child between 0-6 months of age* mushy food daily	child06mushydaily	0.105	0.56
Child between 7-12 months of age* mushy food daily	child712mushydaily	-0.197	-1.11
Child between 13-24 months of age* mushy food daily	child1324mushydaily	**0.422**	1.87
Child between 25-35 months of age* mushy food daily	child2535mushydaily	0.053	0.30
Child between 0-6 months of age* mushy food sometimes	child06mushysometimes	0.020	0.10
Child between 7-12 months of age* mushy food sometimes	child712mushysometimes	-0.100	-0.51
Child between 13-24 months of age* mushy food sometimes	child1324mushysometimes	-0.032	-0.13
Child between 25-35 months of age* mushy food sometimes	child2535mushysometimes	0.062	0.31
Mothers age at birth (years)	momage	**0.282**	2.36
Square of mothers age	sqmomage	-0.003	-1.26
Birth order	bord	**-0.59**	-5.53
Gender	gender	0.0487	0.54
Birth order * gender	Bord*gender	0.027	0.94
Had Diarrhea/fever	diarfever	**-0.167**	-2.98

Table 3: Robust estimates of Weight for age Z score (Village-level fixed effect)

Variables	Abbreviation	Coefficient	T -value
Household-specific factors			
Woman takes health decision	womanpower	-0.024	-0.97
BMI	bmihindu	**0.156**	7.17
Square of BMI	sqbmi	**-0.003**	-5.12
Mother's education: Less than middle	ltmidmot	0.028	0.87
Middle	midmot	**0.070**	1.67
Equal to high school or above	highmot	-0.003	-0.06
Father's education: Less than middle	ltmidfat	**0.066**	2.14
Middle	midfat	**0.072**	2.00
Equal to high school or above	highfat	0.050	1.43
SC/ST	scst	**-0.073**	-2.49
Hindu household	hindu	0.023	0.54
Has electricity	electrichouse	0.019	0.61
Household size	hhsize	**0.015**	4.07
Percentage of children between 0 to 5 years	perchild05	**0.009**	7.09
Percentage of children between 6 to 14 years	perchild614	**0.014**	12.56
Percentage of females equal to or above 15 years	perafe	**-0.007**	-4.34
Owns a kutcha house	kutcha	**-0.065**	-2.13
Open sources of water (well, pond,etc)	openwater	-0.032	-0.89
Not purifying water	notpurify	0.033	0.94
No toilet	notoilet	**-0.089**	-2.46
Owns livestock	ownslivestock	**0.048**	1.79
Size of landholding	sizeland	**0.002**	2.04

Table 4: Robust estimates of Weight for age Z score (District-level fixed effect)

Variables	Abbreviation	Coefficient	t-value
Village-specific factors			
No drainage	nodrainage	-0.042	-1.37
Aganwadi in the village	aganwadi	-0.014	-0.40
Health facility within village	hfvillage	0.045	1.56

Appendix 1. The National Family Health Survey

The NFHS-2 survey (rural), surveyed in 1998/99, collected information from 2531 villages in 25 Indian states[16] from more than 65,000 ever-married women aged 15–49 years and more than 18,000 children under the age of 3 years with respect to nutritional status, especially anthropometric measures-height and weight and anemic status of the last two births since 1995/96 from these eligible women (NFHS–2, 1999/2000). NFHS-2 administered three types of questionnaires: the household questionnaire, the women's questionnaire, and the village questionnaire**.**

The household questionnaire sought information on the demographic composition, including age, sex, marital status, and relationship to the head of the household, education, occupation, and on healthcare seeking behaviour. Also collected were indicators of sanitation, type of housing and ownership of land and other assets.

The woman's questionnaire elicited responses on gender roles, and the treatment of women within the household. Further, information was collected on breastfeeding, feeding practices, and recent occurrences of diarrhoea, fever, and cough for young children.

At each village, a short, open-ended questionnaire was administered to the village head, with questions on perceptions of major problems of the village and possible solutions. It also collected information on the availability of various facilities in the village (especially health and education facilities) and amenities such as electricity and telephone connections.

[16] The survey excluded Tripura because of problems in collecting data.

Appendix 2. Estimation Method

In this paper, we introduce fixed-effect specification at district(d), village(v) and mother levels(m) and control for unobserved heterogeneity and estimate the impact of the explanatory variables at the child, household and village levels. Nutrient intakes, and demographic characteristics such as age, gender and birth order of the child, age of the mother are individual-level factors. Parental education, woman's autonomy, nutritional status, size and composition of the household along with other socio-economic factors are the household-level factors influencing the nutritional status. The living environment is important both at the household and community levels, and is represented by the type of house, source of water, provision of sanitation facilities at the household level; and accessibility to health facilities and sewerage system at the community level. Existence of aganwadi is another community infrastructure facility that is considered. The step-wise estimation of individual, household and village variables is implemented as follows:

(1) In the first step, using the *mother fixed effect* specification, we regress NS_{ihv} on *child-specific characteristics* namely the age, gender, birth order, mother's age, breastfeeding, complementary food, health of the child and some of the interaction dummies. Using these estimates of individual (child) specific variables, we compute the fitted value for nutritional status, $\hat{NS}_{i(\bar{m})}$

(2) In the second step, we compute the *first set of residual* (NS_{hv}) by taking away the effect of child specific characteristics on NS_{ihv} .

$$NS_{hv} = NS_{ihv} - \hat{NS}_{i(\bar{m})}$$

where $\hat{NS}_{i(\bar{m})}$ is fitted value of the standardized weight for age using estimated values for child specific variables.

(3) In the third step, using *village fixed effect specification*, we regress first set of residual NS_{hv} on the *household-specific variables* X_h – education of mother and father, power of mother, nutritional status of the mother, household size and composition, size of the

land holding, type of house, source of water and its purification, availability of toilet, provision of electricity, religion and ethnicity of the household. Using estimated coefficient of household specific variables, we compute the fitted value of standardized weight for age, $\hat{NS}_{h(\bar{v})}$

(4) In the fourth step, we compute *second set of residuals* which now takes away the effect of household-specific variables X_h from standardized weight for age.

$$NS_{v} = NS_{hv} - \hat{NS}_{h\bar{v}}$$

(5) In the fifth step, using *district fixed effect specification*, the second set of residuals, NS_{v} are regressed on the *village variables* to estimate the coefficients of accessibility to health services, existence of aganwadi, and type of sewerage system.

References

Alderman, H. (1990), "Nutritional status in Ghana and its determinants", *Policy Analysis Working Paper 3*, Washington, D.C.

Anderson, M.A. (1981), "Health and nutrition impact of potable water in rural Bolivia", *Journal of Tropical Pediatrics*, vol. 27(1), 39-46.

Attanasio, O., L.C.Gómez, and A.Gómez (2004), "Child health in rural Colombia: Determinants and policy interventions", *Economics and Human Biology*, vol. 2(3), 411-438.

Behrman J.R. (1988a), "Nutrition, health, birth order and seasonality :Intrahousehld allocation in rural India", *Journal of Development Economics*, February 28(1), 43-62.

Behrman, J.R. (1988b), "Intrahousehold allocation of nutrients in rural India: Are boys favored? Do parents exhibit inequality aversion?", *Oxford Economic Papers*, vol. 40, 55-73.

Behrman, J.R. and A.B.Deolalikar (1987), "Will developing country nutrition improve with income? A case study for rural south India", *Journal of Political Economy,* vol. 95(3), 492-507.

Behrman, J.R. and B.L.Wolfe (1982), "Determinants of child mortality, health and nutrition in a developing country", *Journal of Development Economics*, vol. 11, 163-194.

Behrman, J.R. and B.L.Wolfe (1984), "More evidence on nutrition demand: income seems overrated and women's schooling under emphasized", *Journal of Development Economics*, vol. 14, 105-128.

Behrman, J.R. and B.L.Wolfe (1987), "How does mothers' schooling affect family health, nutrition, medical-care usage and household sanitation", *Journal of Econometrics*, vol.36, 185-204.

Behrman, J.R. and E.Skoufias (2004), "Correlates and determinants of child anthropometrics in Latin America: Background and overview of the symposium", *Economics and Human Biology*, vol. 2(3), 335-351.

Checkley, W., et al. (2004), "Effect of water and sanitation on childhood health in a poor Peruvian Peri-Urban community", *The Lancet*, vol. 363.

de Onis, Mercedes, Monika Blossner, Elaine Borghi, Edeward Frongillo and Richard Morris (2004), "Estimates of global prevalence of childhood underweight in 1990 and 2015", J*ournal of the American Medical Association*, vol. 291, No. 21.

Desai, P., K.L Standard, W.E.Miall (1970), "Socio-economic and cultural influences on child growth in rural Jamaica", *Journal of Biosocial Science*, vol. (2), 133-143.

Engle, P., P.Menon, and L.Haddad (1999), "Care and nutrition: Concepts and measurement", *World Development,* vol. 27 (8), 1309–1337.

Esrey, S. A., J. P.Habicht, and G.Casella, (1992), "The complementary effect of latrines and increased water usage on the growth of infants in rural Lesotho", *American Journal of Epidemiology*, vol. 135, 659-66.

Esrey, S.A. (1996), "Waste, water and well-being: a multicountry study", *American Journal of Epidemiology*, vol. 143, 608-23.

Girma, Woldemariam and Timotiows Genebo (2002), "Determinants of Nutritional Status of Women and Children in Ethiopia" (ORC Macro, Maryland).

Greiner, T. and M.C.Latham (1981), "Factors associated with nutritional status among young children in St. Vincent", *Ecology Food Nutrition*, vol. 10, 135-141.

Haddad, L. (1987), "Agricultural household modeling with intrahousehold food distribution: A case study of commercialization in a southern Philippines Province", *Ph.D Dissertation*, Food Research, Stanford University, California, Food Research Institute.

Horton, S. (1986), "Child nutrition and family size in the Philippines", *Journal of Development Economics*, vol. 23(1), 161-76.

Horton, S. (1988), "Birth order and child nutritional status: Evidence from the Philippines", *Economic Development and Cultural Change*, vol.36 (2), 341-45.

Jalan, J. and M.Ravallion, (2001), "Does piped water reduce diarrhoeal disease for children in rural India", *Working Paper No. 2664*, Washington, D.C, USA.

Lavy, V., J.Strauss, and P. de Vreyer (1996), "Quality of health care, survival, and health outcomes in Ghana", *Journal of Health Economics*, vol. 15, 333-357.

Martorell, R., C.Yarbrough, S.Yarbrough and R.E.Klein (1980), "The impact of ordinary illnesses on the dietary intakes of malnourished children", *American Journal of Clinical Nutrition*, vol. 33, 345-50.

Martorell R, Leslie J, Moock P (1984), "Characteristics and determinants of child nutritional status in Nepal", American Journal of Clinical Nutrition ,vol 39, 74-86.

Martorell, R. and J.P.Habicht (1986), "Growth in early childhood in developing countries," in F.Falkner and J.M.Tanner, *Human growth: A comprehensive treatise*, 2nd ed, New York and London: Plenum Press.

Martorell, R., U.Ramakrishnan, D.G.Schroeder, P. Melgar and L.Neufeld (1998), "Intrauterine growth retardation, body size, body composition and physical performance in adolescence", *European Journal of Clinical Nutrition*, vol. 52 (1), S43-S53.

Maxwell,D., et al (2000), "Urban livelihoods and food and nutrition security in Greater Accra, Ghana", *Research Report 112*, International Food Policy Research Institute, Washington, DC.

McGuire, J.B., and B.M.Popkin (1989), *Increasing women's resources for nutrition in developing countries*, 15th session of the ACC/SCN, New York.

McJunkin, F.E. (1982), *Water and human health (USAID)*, Washington, D.C.

Melville, B., et al (1988), "Determinants of childhood malnutrition in Jamaica", *Food and Nutrition Bulletin*, vol. 10(1), 43-47.

Mishra, V.K., S.Lahiri, and N.Y.Luther (1999), "Child nutrition in India", *National Family Health Survey Subject Reports No. 14*, IIPS, Honolulu: East-West Center.

National Family Health Survey Reports (NFHS-2)(1998/99), International Institute for Population Sciences, Mumbai, India.

Olaniyan, O. (2002), "The effects of household resources and community factors on child health: Evidence from Nigeria", Paper prepared for presentation at the CSAE conference on *Understanding Poverty and Growth in Sub-Saharan Africa*, held at St Catharine's College, Oxford March 18/19 2002.

Pitt, M.M., and M.R.Rosenzweig (1985), "Health and nutrient consumption across and within Farm Households", *Review of Economics and Statistics*, vol. 67 (2), 212-222.

Sahn, D. (1990), "Malnutrition in Cote d'Ivoire: Prevalence and determinants", Social Dimensions of Adjustment *Working Paper No. 4*, World Bank.

Smith, L.C., U.Ramakrishnan, A.Ndiaye, L.Haddad and R.Martorell (2003), "The importance of women's status for child nutrition in developing countries", *Research Report 131*, International Food Policy Research Institute, Washington D.C.

Strauss, J. (1990), "Households, communities and preschool children's nutrition outcomes: Evidence from Rural Cote d'Ivoire", *Economic Development and Cultural Change,* vol. 38 (2), 231-62.

Strauss, J. and D.Thomas (1995), "Human resources: empirical modeling of household and family decisions", in J.R.Behrman and T.N.Srinivasan, eds, *Handbook of Development Economics, volume IIIA,* Amsterdam: North-Holland, 1883-2024.

Svedberg, P. (2002), *Poverty and undernutrition: Theory, measurement, and policy*, paperback edition, Oxford University Press, India.

Thomas, D. (1997), "Incomes, expenditures, and health outcomes: Evidence on intrahousehold resource allocation", in L. Haddad, J. Hoddinott, and H. Alderman, Baltimore, Md. ed., *Methods, models, and policy*, Johns Hopkins University Press, International Food Policy Research Institute.

Thomas, D., V.Lavy, and J.Strauss (1996), "Public policy and anthropometric outcomes in the Cote d'Ivoire", *Journal of Public Economics,* vol. 61, 155-192.

United Nations (2006), *Millennium Development Goals Report, 2006*, (New York).
Downloaded from http://www.un.org/millenniumgoals.

UNICEF (1990), "Strategy for improved nutrition of children and women in developing countries", *UNICEF Policy Review Paper*, New York.

Victora, C.G. and F.J.Vaughn (1985), “Land tenure patterns and child health in southern Brazil: The relationships between agriculture production, malnutrition and child mortality”, *International Journal of Health Services,* vol. 15, 253-274.

Walgate, Robert (2002), “Underweight the main cause of ill-health: five causes account for 28% of all DALYs”, *Bulletin of the World Health Organization*, vol. 80, no. 12.

Waterlow, J.C. and Tomkins, A.M. (1992), “Nutrition and infection”, in J.C. Waterlow, ed. *Protein energy malnutrition,* London, Edward Arnold, 290-324.

WHO (1995), Physical status: The use and interpretation of anthropometry, Report of a World Health Organization Expert committee, *WHO Technical Report Series 854*, Geneva.

World Health Organization (1998), “Complementary feeding of young children in developing countries**:** a review of current scientific knowledge”, WHO/NUT/98.1,University of California, Davis, Geneva.

Yimer, G. (2000), “ Malnutrition among children in southern Ethiopia: Levels and risk factor”, *Journal of Health Development,* vol.14 (3), 283-292.