The Role of Maternal Literacy in Reducing the Risk of Child Malnutrition in India

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Abstract

This study uses unit-record data on over 50,000 rural children, from the sixteen major states of India, to analyse the determinants of the risks of severe stunting and of being severely underweight. The importance of this study derives from the fact that the prevalence of under-nourishment in India is, even relative to other poor countries, shockingly high. The study focuses on the role of maternal literacy in reducing the risk of child malnourishment. It concludes that when the mother is literate, real benefits flow to children in terms of reduced risk; the same benefits, however, do not flow when the father, but *not* the mother, is literate. Literate mothers make more effective use of health-care institutions, like *anganwadis* and hospitals. Consequently, the benefits to children from expanding the supply of such institutions are greater when these institutions interact with mothers who are literate.

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1 Introduction

A recurring theme in the literature on the welfare of children in developing countries is the importance of having literate parents and, in particular, of having a literate mother. There is a body of evidence to suggest that the number of children born to a woman is inversely related to her level of education (Borooah, 2000; Parikh and Gupta, 2001; Borooah, 2002). Furthermore, there is considerable evidence to suggest that children's health (including the likelihood of their surviving infancy and childhood), nutritional status and educational attainments are enhanced by having better educated parents, particularly the mother (Behrman and Wolfe, 1984; Thomas, Strauss and Henriques, 1991; Sandiford, Cassel, Montenegro and Sanchez, 1995; Lavy, Strauss, Thomas and de Vreyer, 1996; Ravallion and Wodon, 2000; Gibson, 2001). Evidence also suggests that a farm-household's total income depends upon the highest education level reached by a household member rather than by the mean educational level of the household or by the educational level of the household head (Foster and Rosensweig, 1996). To add to this litany, education also raises the wages of both men and women (Kingdon and Unni, 2001).

Overlaying this theme is another, more recent, theme relating to the nature of literacy. This argues that some of the disadvantages to a person of being illiterate may be mitigated if he/she lives in a household in which other members are literate since, for many activities, having access to the ability of the literate members to read and write may serve as a form of 'surrogate' or 'proximate' literacy. In that sense, an illiterate person living with a literate person(s) may not, by virtue of his/her illiteracy, be so badly off as an illiterate person living in a household in which all are illiterate since, in the former situation, he/she is 'proximate literate' while in the latter situation, he/she is illiterate (Basu and Foster, 1998).

A final twist to the concepts of 'literacy', 'proximate literacy' and 'illiteracy' is provided by Basu, Narayan and Ravallion (2002) who argue that the fact that literate household members are able to confer the benefit of 'proximate literacy' on their illiterate cohabitants gives them a certain 'power' in the process of decision making within the household. Consequently, while household income might be higher when some household members are literate, than when all the members are illiterate, the intra-household distribution of income may be more to the disadvantage of the illiterate members when there are literate members present than when all in the household are illiterate. Consequently, whether proximate literacy benefits the illiterate household members depends on the trade-off between the size of household income and its distribution between the members.

Against this background, the purpose of this study is, firstly, to use unit-record data on over 50,000 *rural* children, from the sixteen major states of India, to analyse the determinants of malnutrition. The data provide anthropometric measures (height-for-age and weight-for-age) for each of the children and relates this information to *inter alia*: the household circumstances of the children, including the quality of the living conditions of the household and the birth orders of the children; the circumstances of the mothers; the quality of the relevant infra-structure available to the households in which the children lived, with particular reference to the quality of the water supply and the availability of hospitals and mother-and-child centres (known in India as *anganwadis*); and the degree of 'food security' that the children's households enjoyed.

These data are based on unit record data from a survey of 33,000 *rural* households - encompassing 195,000 individuals - which were spread over 1,765 villages, in 195 districts, in 16 states of India. This survey - commissioned by the Indian Planning Commission and funded by a consortium of United Nations agencies - was carried out by the National Council of Applied Economic Research (NCAER) over January-June 1994 and most of the data from the survey pertains to the year prior to the survey, that is to 1993-94. Details of the survey - hereafter referred to as the NCAER

Survey - are to be found in Shariff (1999), though some of the salient features of data from the NCAER Survey, insofar as they are relevant to this study, are described in this paper.

The importance of studying the determinants of malnutrition, particularly in the context of children in India, derives from the fact that the prevalence of under-nourishment in India is, even relative to other poor countries, shockingly high. Thus in the 1990s, 36 per cent of children in India below the age of five, compared to 21 per cent in Sub-Saharan Africa were 'severely stunted'[1]; and 49 percent of women between the ages of 20-29 years in India, compared to 21 per cent in Sub-Saharan Africa had a Body Mass Index (BMI) of less than 18.5[2] (Svederberg, 2001). Compounding the suffering that underlie statistics such as these is the "silence with which it is tolerated, not to mention the smugness with which it is sometimes dismissed" (Sen, 2001). This study, therefore, represents an attempt to disturb this quietude.

The second feature of this study obtains from Caldwell (1993) observation - made in the context of the cultural, social and behavioural determinants of health in developing countries - that the educational attainments of women of maternal age had the strongest correlation with health success (measured in terms of life expectancy and rates of infant mortality) and that the task of health transition research was to "explore the mechanics whereby good health was achieved in poor countries and to suggest interventions in other countries based on this knowledge".

In conjunction with this precept, this study explores, in the context of India, the *mechanics* whereby parental literacy in general, but maternal literacy in particular, affects the likelihood of children being malnourished. It does so by allowing the effects of some of the variables, which influence the likelihood of children being malnourished, to vary according to the literacy status of the

[1] Meaning that their height-for-age was below three standard deviations of the WHO norm.
[2] The BMI for a person is defined as the weight (in kilograms) divided by the square of the height (in metres). Adults with a BMI of less than 18.5 are considered to be chronically energy deficient.

mothers. Children, in this study, were distinguished according as to whether their mothers were:

(i) literate;

(ii) 'proximate' literate, that is mother illiterate but father literate;

(iii) illiterate, that is mother and father illiterate

and an important feature of this study is an examination of whether the channels of influence, running through a particular determinant of malnutrition, were different for these three different types of maternal literacy.

In so doing, this study follows in the footsteps of: Thomas, Strauss and Henriques (1991), who studied the relation between maternal education and the height of children in Brazil; Sandiford, Cassel, Montenegro and Sanchez (1995), who studied the interaction between maternal literacy and access to health services in affecting the health of children in Nicaragua; Lavy, Strauss, Thomas and de Vreyer (1996) who examined the relation, for Ghana, between the quality and accessibility of health care, on the one hand, and, on the other, child survival and child health outcomes; and Gibson (2002), who measured the size of the intra-household externality, arising from the presence of literate members in the household, on height-for-age outcomes for children in Papua New Guinea.

However, this study differs in at least three essential respects from this corpus of work. First, and most obviously, it is a study of India - perhaps, the first study of child malnutrition in India based on unit record data - where, as noted above, the incidence of child malnutrition, both in terms of severity and in terms of numbers involved, is particularly acute. Indeed, as Shariff (1999) observes, "there is scope to undertake a comprehensive analysis of the determinants of malnutrition among children in India" (p. 96). Second, it examines the relation between the circumstances of mothers and the likelihood of their children being undernourished. This resonates with the argument, recently made by Osmani (2001), that the undernourishment of children in India begins in the womb and can be traced to discrimination against women. Thirdly, it focuses on the influence of household food security - as measured by the size of a household's food stocks and its access to fair price shops - on child malnutrition. This issue is particularly important today in India because there has been a progressive dismantling of the fair shop system whereby households could buy food at subsidised prices. Indeed, it is ironical that the very system of higher producer prices that has resulted in a record stockpile of 62 million tonnes of food grains in India has kept food away from the reach of poorer consumers.

The fact that children from different (parental) literacy backgrounds had different health outcomes could be due to the beneficial effects of literacy *per se* but it could also owe to the fact that inter-children differences in (parental) literacy backgrounds were reflected in differences between the children in the quality of their 'health-friendly' environment. If, for example, household income was a significant determinant of health outcomes and literate persons were more likely to have higher incomes than illiterate persons, then one would expect to see differences in health outcomes between children with literate and illiterate parents without any appeal to the role of literacy in influencing these outcomes. Call this the 'attribute effect'. On the other hand, children, faced with the same health-related environment, might have different health outcomes simply because literate parents were better at turning a specific environment to their children's advantage than were parents who were illiterate. Call this the 'literacy effect'. The health outcome for children is, of course, the consequence of an amalgam of both effects. The crucial task is then to estimate, after disentangling the two effects, the relative contributions of attribute and literacy effects on the health outcomes of children in India.

2 Model specification

As Thomas, Strauss and Henriques (1991) have observed, models of child health outcomes have attempted to integrate the biomedical approach - which views health outcomes in terms of a production process into which several factors enter as inputs - with a model of the family (Becker, 1981). This results in reduced form child health functions being estimated. Underlying these reduced forms is the assumption that households maximise a quasi-concave utility function - which depends on consumption, leisure and the quantity and quality of children - subject to a household budgetary constraint, individual time constraints and the constraint of the child health production function (Behrman and Deolalikar, 1988). The inputs entering into the production function are *inter alia*: the child's diet (including the length of breastfeeding and the age at which the child is introduced to supplementary foods); the quality of health-related infrastructure (including the quality of the water supply and the availability of medical attention and dietary advice); the level of sanitation in the home.

In this model, the demand for child health (H_i) will depend upon the vector of child characteristics ($\mathbf{X_i}$); the vector of household or parental characteristics pertaining to the child ($\mathbf{W_i}$); and the relevant community characteristics vector ($\mathbf{V_i}$). Consequently,

$$H_i = H(\mathbf{X_i}, \mathbf{W_i}, \mathbf{V_i}) \quad (1)$$

The NCAER Survey provided data on two anthropometric measures for the health outcomes of children (between the ages of 0-12 years) in the sample:

(i) Height-for-Age defined as: $S_i^* = (h_i - m_h)/s_h$ where h_i is the height of the child; μ_h is the age and sex specific reference median height[3]; and σ_h is the standard error of the distribution of heights.

(ii) Weight-for-Age defined as: $R_i^* = (w_i - m_w)/s_w$ where w_i is the weight of the child; μ_w is the age and sex specific reference median weight[4]; and σ_w is the standard error of the distribution of weights.

Following from these measures, a child is regarded: as 'severely stunted' when S_i^* < -3 and 'mildly stunted' when -3 $\leq S_i^*$ $\leq$ -2; as 'severely underweight' when R_i^* < -3 and 'mildly underweight' if -3 $\leq R_i^*$ $\leq$ -2 (World Health Organization, 2000).

Using the anthropometric data, the binary variables, S_i and R_i were defined as:

(a) $S_i = 1$ if $S_i^* < -3$ (child is severely stunted), $S_i = 0$, otherwise

[3] National Centre for Health Statistics (NCHS) standards.
[4] National Centre for Health Statistics (NCHS) standards.

(b) $R_i = 1$ if $R_i^* < -3$ (child is severely underweight), $R_i = 0$, otherwise

Hereafter, the terms 'stunting' and 'underweight' are used in this paper to mean 'severe stunting' and 'severely underweight'.

Next, the bivariate probit model was specified as:

$$\begin{aligned} S_i &= a_0 + a_0^P + a_0^L + \sum_{j=1}^{J} a_j z_{ij} + \sum_{j=1}^{J} a_j^P (PX_i * z_{ij}) + \sum_{j=1}^{J} a_j^L (ML_i * z_{ij}) + e_i^h \\ &= 1 \text{ if } S_i^* \le -3, \;\; S_i = 0, \text{ otherwise} \\ R_i &= b_0 + b_0^P + b_0^L + \sum_{j=1}^{J} b_j z_{ij} + \sum_{j=1}^{J} b_j^P (PX_i * z_{ij}) + \sum_{j=1}^{J} b_j^L (ML_i * z_{ij}) + e_i^w \\ &= 1 \text{ if } R_i^* \le -3, \; R_i = 0, \text{ otherwise} \end{aligned} \quad (2)$$

where:

- z_{ij} is the value of the j^{th} determining variable for the i^{th} child (j=1…J, i=1…N)
- PX_i=1, if the child's mother is illiterate, but the father is literate (that is, the mother is proximate literate); PX_i=0, otherwise
- ML_i=1, if the child's mother is literate; ML_i=0, otherwise
- e_i^h and e_i^w are the error terms, such that:

$E(e_i^h) = E(e_i^w) = 0;\; Var(e_i^h) = Var(e_i^w);\; \text{cov}(e_i^h) = \text{cov}(e_i^w) = r$.

The specification of the model as a bivariate probit allows the error terms to be correlated within the context of a binary dependent variable.

The coefficients α_j and β_j in equation (2) are the coefficients on the j^{th} determining variable for children whose both parents are illiterate; the coefficients α^P_j and β^P_j in equation (2) represent the additional effect (over α_j and β_j) of the j^{th} variable that arises for children whose mother is 'proximate' literate; and the coefficients α^L_j and β^L_j in equation (2) represent the additional effect (over α_j and β_j) of the j^{th} variable that arises for children whose mothers are literate.

3 Measuring Literacy Effects

Three scenarios were constructed in order to quantify the effects of community on the number of pregnancies. In the first, ‘all illiterate’ (I), scenario *all* the N children in the stunting and underweight equations were assumed to have illiterate parents. In the second, ‘all proximate literacy’ (P), scenario all the N children were assumed to have illiterate mothers and literate fathers and in the third, ‘all-literate’ scenario (L), the mothers of all the N children were assumed to be literate. If p_i^k and q_i^k (k= I, P, L) represent the (estimated) probabilities of a child being, respectively, stunted and underweight, then the difference between the p_i^k (and between the q_i^k) across the scenarios is *entirely* due to differences in maternal literacy status since nothing was changed between the three scenarios *except* the literacy status of the mothers.

The mean values of the p_i^k and q_i^k, denoted respectively p^k and q^k, may be termed the average ‘literacy-determined’ probabilities of being, respectively, stunted and underweight and $l^k = p^I - p^k$ and $m^k = q^I - q^k$ may be termed the 'literacy determined’ probability surpluses (of being, respectively, stunted and underweight) of children with illiterate mothers over children with mothers who are literate (k=L) or who are 'proximate literate' (k=P). If $\bar{p}^k$ and $\bar{q}^k$ are the *observed* proportions of children, with mothers in literacy status k, (k=I,P,L) who are, respectively, stunted and underweight, then the observed probability surpluses (of children with illiterate mothers over children whose mothers are literate or proximate literate) of being stunted (Ω^k) and underweight (Φ^k) can be decomposed as:

$$\begin{aligned}\Omega^k &= \bar{p}^I - \bar{p}^k = \bar{p}^I - p^I + p^I - p^k + p^k - \bar{p}^k \\ &= p^I - p^k + [(\bar{p}^I - p^I) - (\bar{p}^k - p^k)] = l^k + \boldsymbol{p}^k \text{ where: } k = P, L \\ \\ \Phi^k &= \bar{q}^I - \bar{q}^k = \bar{q}^I - q^I + q^I - q^k + q^k - \bar{q}^k \\ &= q^I - q^k + [(\bar{q}^I - q^I) - (\bar{q}^k - q^k)] = m^k + y^k \text{ where: } k = P, L\end{aligned} \tag{3}$$

The term π^k and ψ^k in equation (3) can be interpreted as the 'attribute-determined' probability surpluses of children with illiterate mothers over children with mothers who are either literate (k=L) or 'proximate literate' (k=P). If $\pi^k = 0$, then $\Omega^k = \lambda^k$ and the observed probability surplus (of being stunted) is equal to the 'literacy-determined' surplus. But if $\pi^k \neq 0$, then $\Omega^k \neq \lambda^k$: interposing between the observed and the 'literacy-determined' surpluses is the effect of differences between children with illiterate mothers and children with mothers who are literate/proximate literate in their respective endowments of the other factors which affect the likelihood of being stunted. If $\Omega^k > \lambda^k$ (that is, $\pi^k > 0$), these attribute differences *add to* the literacy-determined surplus; on the other hand, if $\Omega^k < \lambda^k$ ($\pi^k < 0$), these differences *subtract from* the literacy-determined surplus.

4 The Data and Equation Specification

The data used for estimating the bivariate probit equations, whose dependent variables were described above, were obtained from the NCAER survey, referred to earlier. The salient features of these data are set out in this section. The data from the NCAER survey are organised as a number of 'reference' files, with each file focusing on specific subgroups of individuals. However, the fact that in every file an individual was identified by a household number and, then, by an identity number within the household, meant that the 'reference' files could be joined – as will be described below – to form larger files.

So, for example, the 'stunting' and 'underweight' equations were estimated on data from the 'children' file. This file, as the name suggests, gave information on those individuals in the sample who were between the ages of 0-12, with particular reference to their health-related environment (for example, their diet). In particular, this file contained information on the heights and the weights of children as z-scores. These z-scores were then used, as described in section 2, to construct the binary variables S_i and R_i.

To the children's file was appended the 'household file': this associated with each child, information on the circumstances (economic, social, housing) of his/her household. Also appended to the children's file was the 'food security file': this gave *inter alia* information on whether the household (in which the child lived) had access to fair price shops and also on the size of the household's food stocks. Appending the 'eligible women's file' - which contained information on the women in the Survey who were of reproductive age - to the children's file meant that information on the child's mother could be associated with existing information on the child. The final appendage to the children's file was the ‘village file’ which contained data relating to the existence of infrastructure in, and around, each of the 1,765 villages over which the survey was conducted: this then yielded information on the health-related infrastructure in, and around, the village in which the child lived.

As observed earlier, the vector of determining variables $\mathbf{z_i}$ for the i^{th} child (i=1…N) could be partitioned into those which related to: the child's characteristics ($\mathbf{X_i}$); the child's household or parental characteristics ($\mathbf{W_i}$); the characteristics of the community within which the child lived ($\mathbf{V_i}$).

The child's characteristics were specified in terms of the following variables:

(i) **sex**=1 if the child was female

(ii) **age** and **age^2**. Even though, the dependent variable controls for the age of children, Gibson (2002) and Thomas and Strauss (1992) have pointed to the importance of including age as an explanatory variable. The square of age was included in order to allow for possible non-lineararity in the effect of age on the likelihood of being stunted/underweight.

(iii) The age (in months) at which the child had been introduced to soild foods (**sfa**). The expectation was that the later the age, the higher the probability of being stunted/underweight.

(iv) The age (in months) till which the child had been breastfed (**bmk**). The expectation was that the later the age, the lower the probability of being stunted/underweight.

The household parental characteristics were specified in terms of the following characteristics:

(i) Whether the child's mother was literate (**ML**), proximate literate (**PX**); or illiterate.

(ii) The spacing of the mother's pregnancies (**spg**), defined as the number of years married divided by the number of pregnancies.

(iii) The age of the mother at marriage (**agm**).

(iv) The birth order of the child (**bod**).

(v) The sex of the head of household (**hsex**=1, if head was female).

(vi) Whether women in the household were empowered: **emp**=1, if a female member of the household, at least 1-2 days per week: read a newspaper; or listened to the radio; or watched television.

(vii) Whether the household was a poor household: **pov**=1, if household income was below the poverty line[5].

(viii) The size of the household's food stocks in kgs (**fst**).

(ix) Whether the household had access to a fair price shop: **fps**=1, if it did.

(x) The existence and quality of a toilet in the house: **tol**=1, if there was either no toilet in the house or it was manual.

(xi) The quality of housing condition of the household: **phs**=1, if housing conditions were poor, defined as an absence of a separate kitchen, with no ventilation while cooking, with food being cooked on an open charcoal/wood burning stove (*chula*).

The community level characteristics were defined in terms of:

(xii) Whether the household had access to safe drinking water: **water**=1, if it was not safe[6].

(xiii) Whether the household had easy access to a hospital or a sub-station of a household: **hsp**=1, if it did have such access[7].

(xiv) Whether there was an *anganwadi* in the village: **angw**=1, if there was. *Anganwadis* are village-based early childhood development centres. They were devised in the early 1970s as a baseline village health centre, their role being to: provide government-funded food supplements to pregnant women and children under five; to work as an immunisation outreach agent; to provide information about nutrition and balanced feeding, and to provide vitamin supplements; to run

[5] The NCAER Survey provided information on the incidence of household poverty.
[6] If the household's source of drinking water was from ponds, running streams or wells.
[7] Defined as a hospital within 5km of the household's village and/or a sub-station within the village.

adolescent girls' and women's groups; and to monitor the growth, and promote the educational development, of children in a village.

Table 1 shows the distribution of some of these characteristics across the 53,207 children analysed. Of the 53,207 children, between the ages of 0-12 years, that were analysed, 43% were stunted and 9% were underweight (that is their z-scores<-3). Of the children that were underweight, 81% were stunted and, of the children that were stunted, 16% were underweight. The incidence of stunting and of being underweight was lower for girls than it was boys: 42% versus 44% for stunting and 7% versus 10% for boys.

The incidence of stunting and of being underweight was also lower for children with literate mothers (40% and 7%) than it was for children whose mothers were illiterate or proximate literate. However, there was no difference in the incidence of stunting and of being underweight between children whose mothers were illiterate and those whose mothers were proximate literate. Of the total number of children, 27% had literate mothers, 30% had mothers who were proximate literate and the remainder (43%) had illiterate mothers.

In addition to benefiting from having literate mothers, children also benefited from living in households where at least one of the women was 'empowered' (in the sense defined earlier) and, in particular, they benefited from living in households headed by a female. Women were 'empowered' in 47% of households and 4% of households were headed by a woman. Living in a poor household (22% of children lived in poor households) also raised the incidence of being stunted and of being underweight. However, the fact of living in a household without access to a fair price shop made an even bigger impact on these two incidences than did living in a poor household: the incidence of stunting was 47% among (the 8% of) children living in households without access to a fair price shop, as compared to 42% for children living in households that did have access to such shops.

Differences in living conditions were reflected in differences in the incidence of stunting and being underweight: a higher proportion of children living in households with poor toilet facilities and with poor cooking facilities were stunted and underweight than children who did not live in similarly handicapped households[8].

The provision of infrastructure - by way of safe drinking water, hospitals and *anganwadis* - reduced the incidence of both stunting and being underweight: safe drinking water had the biggest impact on the incidence of being underweight while the presence of *anganwadis* in villages and relatively easy access to hospitals had the biggest impact on the incidence of stunting.

5. Econometric Results

The results from estimating the bivariate probit model (set out in equation (2)), using as determining variables those delineated in the previous section, are shown in Table 2 with the equation statistics shown in Table 3. The first thing to note from Table 3 is that the null hypothesis, of no correlation between the error terms of the stunting and the underweight equations, could not be accepted; the correlation coefficient was estimated to be 0.48. This suggests that it was, indeed, more appropriate to estimate the equations as a system of Seemingly Unrelated Equations rather than to estimate them individually.

A positive coefficient estimate in Table 2 indicates that the likelihood of being stunted/underweight increases - while a negative coefficient estimate in Table 2 indicates that the likelihood of being stunted/underweight decreases - for an increase in the value of the associated variable. A variable, which was not an interaction term (that is, was of the form, z_i), was included in the estimated equation if the z-score associated with its coefficient was greater than 1; on the other hand, interaction terms (of the form: z_i*PX_i or z_i*ML_i) were included only if they were significantly different from zero at a 10% level of significance.

[8] 88% of children lived in households with poor toilet facilities and 50% of children lived in households with poor cooking facilities.

The main conclusions that emanate from the estimated bivariate probit model (Table 2) may be summarised as follows, all the results being reported on a *ceteris paribus* basis:

(i) The likelihood of being stunted and underweight was lower for girls than for boys. In this connection, Lavy et. al. (1996) also reported that the height-for-age and the weight-for-age were lower for male children in Ghana; on the other hand, Gibson (2001) did not find any significant gender difference between the height-for-age of children in Papua New Guinea.

(ii) The higher the birth order of a child, the greater the likelihood of it being stunted/underweight. To the best of our knowledge the importance of birth order to child malnutrition has not been previously considered in the literature.

(iii) Children living in female-headed households were less likely to be stunted/underweight than children living in male-headed households. Again, Lavy et. al. (1996) reported that the height-for-age and the weight-for-age of children were higher for female-headed households.

(iv) The later a child was introduced to solid foods, the greater the likelihood of it being stunted/underweight; on the other hand, the longer it was breast-fed, the smaller the likelihood of it being stunted/underweight. As Bellamy (1998) concludes "a child must have complementary foods at the six-month point …delaying the switch-over [from breast milk] can cause a child's health to falter" (p.28). On the other hand, as she goes on to say, "exclusive breast feeding for the first six months provides the best nourishment and protection from infection" (p.29).

(v) Household poverty had no significant effect on the likelihood of a child from that household being stunted, but it did significantly raise the likelihood of a child from that household being underweight. This is consistent with some studies but not with others: Lavy et. al. (1996) reported that in Ghana "expenditure as a measure of resource availability is not a significant determinant of child height" though Gibson (2001) found there to be a significant relation between percapita household expenditure and children's height-for age in Papua New Guinea.

(vi) The size of a household's stock of food-grains and its access to a fair price shop were inversely related to the likelihood of a child from that household being stunted, but neither variable had an effect on the likelihood of being underweight. Smith and Haddad (2000) in a cross-country analysis using country-level data emphasised the role of food security for ensuring good nourishment: our results confirm, but also refine, this result in the Indian context.

(vii) Poor housing conditions - in the sense of poor cooking conditions - affected the likelihood of being underweight but not the likelihood of being stunted. Thomas et. al. (1991) also emphasised the importance of housing conditions for child malnutrition in Brazil and argued that "children are shorter in communities which rely on rudimentary sewage systems" (p. 207).

(viii) Children from households with one, or more, 'empowered' females, defined earlier, were less likely to be stunted and to be underweight than children from other households. Again, Thomas et. al. (1991), in the context of Brazil, emphasised the importance of women's access to information through reading newspapers, watching television and listening to the radio. This is equally true in India.

(ix) The greater the spacing of a mother's pregnancies, the less likely it would be that her children were stunted. Most studies do not - cannot - relate children's nutritional outcomes to the medical history of the mother. This study is a small exception: even though data on the medical past of the mother is sketchy, the results are able to point to the importance of foetal malnutrition (caused by births following each other too closely) on child development.

Among these effects, there were three instances where the influence of a variable varied according to the literacy of the mother:

(a) Although the likelihood of a child being stunted/underweight increased with its birth order, the effect of birth order on stunting, compared to a situation in which the mother was illiterate, was moderated when the mother was literate, though not when the mother was proximate literate.

(b) The presence of *anganwadis* in a villages and the easy access to hospital facilities both reduced the likelihood of stunting, even when the mothers were illiterate; however, the reduction in this likelihood, flowing from the presence of these facilities, was particularly marked when the mothers of the children were literate.

(c) Easy access to hospitals only reduced the likelihood of children being underweight when their mothers were literate; the presence of village *anganwadis* only reduced the likelihood of children being underweight when their mothers were literate or proximate literate, the influence of literacy being stronger than that of proximate literacy.

Findings (b) and (c), above, are consistent with - and, indeed, corroborate - Caldwell's (1993) observation that, in the context of developing countries, three areas are of critical importance to a child's health. Firstly, an educated mother assumes the responsibility of taking a sick child to a health centre; by extension, educated mothers, more than illiterate mothers, take advantage of the advice and information on child care and health available from *anganwadis*. Second, the time that mothers spend discussing their child's illness with a doctor is almost directly proportional to their level of education: in consequence, illiterate women (and their sick children) get much less out of visiting a doctor than do literate women. Lastly, when a currently prescribed course of treatment for a child proves to be ineffective, illiterate mothers, relative to literate mothers, are less inclined to report this to their doctor. Collectively, these observations imply that the effectiveness of health-care organisations to child health is enhanced when their services are complemented by mothers who are literate.

6. The Effects of Maternal Literacy on Stunting and Low Weight

Table 4 shows the effects of maternal literacy on the likelihood of children being stunted and being underweight. The first column of Table 4 suggests that if all the 53,207 children in the sample had had literate mothers, then the likelihood of their being stunted and being underweight would have been, respectively, 40% and 7%. In terms of the notation of section 3, these are the estimated values of p^L and q^L of equation (3). The observed sample proportions of children with literate mothers who were stunted and who were underweight are shown parenthetically in Table 4. The numbers in parentheses are the $\bar{p}^L$ and $\bar{q}^L$ of equation (3). Since, as Table 4 shows, $p^L = \bar{p}^L$ and $q^L = \bar{q}^L$ the conclusion is that children with literate mothers did not have any 'attribute' advantage over other children[9]. In the notation of equation (3), $p^L = y^L = 0 \Rightarrow \Omega^L = l^L; \Phi^L = m^L$ If children with literate mothers had had an attribute advantage/disadvantage over other children, then their 'maternal literacy' advantage would have been boosted/dampened by their attribute advantage/disadvantage leading to, in the case of attribute advantage, the observed likelihoods $\bar{p}^L \text{ and } \bar{q}^L$ being less than the corresponding 'synthetic' likelihoods, p^L and q^L.

A similar conclusion holds with respect to children whose mothers were, respectively, proximate literate and illiterate. In both instances, the *sample proportion* of children, in these categories, who were stunted and underweight were the same as the likelihoods that would apply when *all* the children had mothers who were proximate literate/illiterate. In the notation of section 3: $p^P = \bar{p}^P$ and $q^P = \bar{q}^P$; $p^I = \bar{p}^I$ and $q^I = \bar{q}^I$ so that: $p^k = y^k = 0 \Rightarrow \Omega^k = l^k; \Phi^k = m^k, k = P, I$.

However, as Table 4 indicates, children whose mothers were illiterate had a 'literacy-determined' surplus (in their likelihood of being stunted/underweight) over children whose mothers were literate: this surplus amounted to 4 percentage points (pp). By contrast, children whose mothers were illiterate

[9] 'Attribute' here means the collective of non-literacy related attributes.

did not suffer any disadvantage, relative to children whose mothers were proximate literate: since $p^I=p^P$, the literacy-determined surplus of children with illiterate mothers, over children with proximate literate mothers, was zero.

This last finding harks to the trade-off - to which Basu, Narayan and Ravallion (2002) drew attention - that illiterate persons in households containing literate individuals could face, between higher family income but lower individual shares. Basu, Narayan and Ravallion (2002) found a positive externality associated with proximate literacy - after controlling for other variables, an illiterate household member earned significantly more in the non-farm sector in Bangladesh when there were literate household members present than when there were not. So indeed did Gibson (2001), in the context of children's height-for-age in Papua New Guinea: he concluded that the size of the externality provided by literate, to illiterate, members through proximate literacy was large. By contrast, this study's conclusion is that while, in general, the empowerment and the position of women in the household and, in particular, the literacy of mothers, was important for reducing the risk of children being stunted or underweight, maternal illiteracy exercised the same degree of influence, whether or not the father of the child was literate.

7. The Provision of Health-Care Facilities and the Risk of Stunting and Low Weight

Earlier, the point was made that the effectiveness of the supply of health-care facilities, on reducing the likelihood of children being stunted and being underweight, depended upon whether or not the mothers of these children were literate. These issues are quantified in this section. The basic counterfactual situation considered was one in which every village had both an *anganwadi* and also easy access to hospital facilities. This basic counterfactual situation was then combined with three possible counterfactual scenarios relating to maternal literacy: (i) all the mothers were literate; (ii) all the mothers were proximate literate; and (iii) all the mothers were illiterate.

Table 5 shows the likelihood of children being stunted and being underweight when the supply-side counterfactual scenario was combined with each of three demand-side scenarios. This shows that when all mothers were literate, the universal provision, to every village, of an *anganwadi* and of easy access to hospital facilities would lower the risk of stunting to 38% (from the sample average of 43%) and the risk of being underweight to 6% (from the sample average of 8%). This reduction is the consequence of improved health-care facilities meeting universal maternal literacy. When, however, improved health-care facilities were met by universal maternal proximate literacy or by universal maternal illiteracy, the likelihood of being stunted was 43% (which coincidentally was also the sample proportion). The benefits of improved facilities were negated by losing the advantage in having (some) literate mothers when they were universally replaced by mothers who were proximate literate or illiterate. (The likelihood of being underweight was slightly lower when all mothers were assumed to be proximate literate than when they were assumed to be illiterate because of the presence, in the underweight equation, of the interaction term between *anganwadis* and proximate literacy).

8. Conclusions

This paper employed a bivariate probit model to estimate equations for risk of rural children in India being stunted and being underweight. Estimating the equations as a system allowed the estimation process to take account of the correlation between the unobserved error terms of the two equations - as was seen, this correlation was considerable. In so doing, this study of child malnutrition in India - employing unit record data for over 50,000 children - represents a rare, if not the only, country-wide analysis for India based on individual data.

A particular feature of interest was the role of maternal literacy in reducing the risk of child malnutrition and, more specifically, the channels through which this risk reduction might operate. The results indicated that literate mothers made more effective use of health-care institutions - for reasons discussed earlier - than illiterate mothers. This is national finding is conceptually consistent with an earlier result from Caldwell et. al. (1983) that young mothers in South India, who had been to school, were more likely to demand of their husbands and mothers-in-law that a sick child be treated.

This finding, it was argued, meant that the effectiveness of supply-side factors (more hospitals, more *anganwadis*) depended also upon the effectiveness with which the users employed such institutions. In particular, the value of such institutions to children would be considerably enhanced if the end-users, in the form of the children's mothers, were literate.

More generally, the study pointed to the importance of the role that women played within the household. Households that were headed by women or those in which the women had access to information - through newspapers, radio and television - would have better-nourished children than households in which women were not empowered. Sadly, the study reported that, when it came to the nutritional well-being of the children, the literacy of the father was a poor substitute for the literacy of the mother. In order to reduce the risk of children in India being stunted or underweight it was far more important that the mothers be actually literate than simply have literate husbands. This is the central conclusion of this paper.

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Table 1
Selected Data for Severely Stunted and Severely Underweight Children, 0-12 years

	% children stunted	% children underweight
All children (53,207)	43	9
All boys (27,765)	44	10
All girls (25,442)	42	7
Mother literate	40	7
Mother proximate literate	44	9
Mother illiterate	44	9
Households with poor toilets	43	9
Households with adequate toilets	40	6
Households with poor cooking facilities	44	10
Households with adequate cooking facilities	42	7
Household Head female	38	6
Household Head female	43	9
Households with empowered females	42	8
Households with not empowered females	44	10
Poor household	44	9
Non-poor household	42	8
Households with access to Fair Price Shops	42	8
Households without access to Fair price Shops	47	9
Households with unsafe water	44	10
Households with safe water	42	8
Hospital within 5km	42	8
No hospital within 5 km	45	9
Anganwadi in villane	42	8
No Anganwadi in villane	44	9

Source: NCAER Survey

Table 2
Bivariate Probit Estimates of the Stunting and Underweight Equations

	Stunting	Underweight
Age	-0.1466115 (19.42)	-0.564651 (4.44)
age^2	0.0067737 (12.23)	-0.0158592 (11.53)
Sex	-0.0534501 (4.83)	-0.3194747 (17.57)
birth order	0.0109082 (3.20)	0.0241039 (4.95)
birth order * mlit	-0.0111094 (1.83)	- -
sex of hoh	-0.0828648 (2.88)	-0.1057504 (1.95)
age at solid foods intake	0.0136627 (2.88)	0.0434836 (8.71)
age till given breast milk	-0.0373337 (6.42)	-0.0225344 (3.62)
poor household	0.0160976 (1.18)	0.0451513 (2.10)
unsafe drinking water	0.0196769 (1.58)	0.0624639 (3.17)
easy hospital access	-0.0260958 (2.02)	- -
easy hospital access * ml	-0.0547708 (2.43)	-0.0910527 (3.21)
anganwadi in village	-0.0224904 (1.76)	- -
anganwadi in village*px	- -	-0.0714305 (2.77)
anganwadi in village*ml	-0.063942 (2.78)	- -
stock of food grains	-0000242 (2.02)	- -
access to fair price shop	-0.0810994 (4.14)	- -
poor housing	- -	0.074794 (4.01)
no vaccination	0.0326996 (1.15)	- -
females empowered	-0.031174 (2.65)	-0.0633504 (3.29)
mother's spacing of pregnancies	-0.0068982 (2.31)	- -
mother's age at marriage	0.0026539 (1.28)	- -
Intercept	0.51055 (9.93)	-0.7175276 (19.06)

z-values in parentheses

Table 3
Equation Statistics: Stunting and Underweight Equations

Number of Observations	53,207
Wald Test: $\chi^2(34)$	5509.29
Estimate of ρ	0.4818963
LR test of ρ=0: $\chi^2(1)$	1871.84

Table 4
The Likelihood of Children Being Severely Stunted and Underweight Under Different Maternal Literacy Scenarios

Literacy Scenario→ Probability of ↓	Mother Literate	Mother Proximate Literate	Mother Illiterate
Stunted	40 (40)	44 (44)	44 (44)
Underweight	7 (7)	8 (8)	9 (9)

Figures in parentheses represent sample proportions

Table 5
The Effects of Health-Care Facilities on Stunting and Low Weight

	All Villages Have an Anganwadi and Also Easy Access to Hospital Facilities		
	All Mothers Literate	All Mothers Proximate Literate	All Mothers Illiterate
Likelihood of Children Being Stunted	38	43	43
Likelihood of Children Being Underweight	6	8	9