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DETERMINANTS OF NUTRITIONAL STATUS OF PRE-SCHOOL CHILDREN IN INDIA

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Summary. The aim of this paper is to assess the spatial distribution of nutritional status of children of less than three years through *Z*-scores of weight-for-age, height-for-age and weight-for-height using data collected by the National Family Health Survey (NFHS-2, 1998–99), India. The nutritional status of pre-school children was regressed on different socio-demographic factors after eliminating the effect of age. The data show that there are gender differences and spatial variations in the nutritional status of children in India. Gender difference is not very pronounced and almost disappears when the effects of age and socio-demographic variables are removed. The spatial difference, especially the rural–urban difference, was found to be very large and decreased substantially when the effects of age and socioeconomic variables were removed. However, the differences were not close to zero. All the variables were found to affect significantly the nutritional status of children. However, the literacy of mothers did not affect height-for-age significantly. The weight-for-age and height-for-age scores showed a dismal picture of the health condition of children in almost all states in India. The worst affected states are Bihar, Madhya Pradesh, Orissa and Uttar Pradesh. Assam and Rajasthans are also lagging behind. Weight-for-height scores do not give a clear picture of state-wise variation. Goa, Kerala and Punjab are the three most developed states in India and also have the lowest percentages of underweight children according to the *Z*-scores. Along with these three states come the north-eastern states where women are well educated. Thus overall development, enhancement of level of education and low gender inequality are the key factors for improvement in the health status of Indian children.

Introduction

Malnutrition of under-five children is one of the most serious health problems in developing countries. The term malnutrition includes both undernutrition and overnutrition, but normally malnutrition is synonymous with undernutrition. Childhood undernutrition may lead to concurrent and delayed intellectual and motor development, deficiency in growth and other adverse health effects (Lloyd-Still *et al.*,

1974). It is reported that 55% of the deaths of children below five years of age is due to malnutrition (UNICEF, 1994). Out of four Asian countries – Bangladesh, India, Pakistan and Sri Lanka – the prevalence of under-five malnutrition is higher in Bangladesh and India than in Pakistan and Sri Lanka (UNICEF, 2001). India has the highest occurrence of childhood malnutrition in the world (Bamji, 2003). In developing countries, the proportion of malnourished children has been reduced by 20% over the last 30 years (WHO, 1997; Smith & Haddad, 2000). In India, 52% childhood malnutrition during 1992 reduced to 47% during 1998 (IIPS & ORC Macro, 2000). Comparing data on three states in India, namely Andhra Pradesh, Maharashtra and Kerala, one sees that the children of Kerala suffered the least from malnutrition, which may be due to the high level of female literacy (NFHS-2, 1998–99). Mention may be made here that Kerala has the highest female literacy in India. In a recent study by the World Bank, Gragnolati *et al.* (2005) reported that the percentage of underweight children is higher in rural areas than in urban areas. They also showed concern for the gender disparities in nutritional levels, and found large inter-state variation in the patterns and trends in underweight.

Malnutrition is associated with poverty and disease. So, the three factors, viz. malnutrition, poverty and disease, are interlinked in such a way that each contributes to the presence and sustained effect of the other. Due to poverty, a significant portion of the population is unable to procure enough food. And ultimately, they become malnourished and vulnerable to diseases like diarrhoea and parasitic infection. These often result from poor sanitation and drinking water facilities. Frequent attacks of diarrhoea and parasitic infection due to the poor health status of children and poor sanitary conditions ultimately lead to further aggravation of disease (Dasgupta *et al.*, 2005). The Government of India has taken some measures to increase access to food. Firstly, the Public Distribution System (PDS) provides some staple foods such as food grains and sugar at a controlled price (Nawani, 1994). Secondly, people working on building projects or maintaining public infrastructure are often paid in food grains. The third step is mid-day meal programmes for school-going children (Government of India, no date).

Child growth is a function of food intake and nutrition absorption, health condition and prevalence of disease of the child as well as the socioeconomic and ecological environment in which the child lives and grows. So, these interactions are inseparable and should be handled methodically in any anthropological model. Status of growth is the best indicator of health and nutritional status of children. Anthropometry is recognized as the most useful technique to assess the growth and nutritional status of individuals or populations (Jelliffe, 1966; Rao *et al.*, 1986; Gorstein *et al.*, 1994; de Onis *et al.*, 2004; WHO, 1995; Borooah, 2005), because anthropometric measures are highly sensitive to undernutrition (Martorell & Ho, 1984).

In India, many studies have been conducted on the nutrition and health status of pre-school children, but they are very scarce on the causative factors of malnutrition. Rajaram *et al.* (2003) assessed the nutritional status of pre-school children in Kerala and Goa and found a significant relationship between socioeconomic variables and degree of malnutrition. A similar type of study was also done in north-east India by Rao *et al.* (2004).

The main objectives of this study are: (i) to assess the geographical variations of nutritional status through the nutritional indices (*Z*-scores) of weight-for-age, height-for-age and weight-for-height of children separately for each age; (ii) to assess the effect of socioeconomic variables on the nutritional status of children in India; (iii) to determine whether the gender disparities and geographical variations in nutritional status can be attributed to the age of children and/or socio-demographic variables.

Subjects and Methods

The data on growth and nutritional status of children were accessed from the second National Family Health Survey (NFHS-2) conducted by the International Institute for Population Sciences (IIPS), Mumbai, in 1998–99. The NFHS-2 sample covers the Indian population of ever-married women in the age group 15–49 years living in 26 states. This survey collected data on weight and height of the youngest children below the age of 36 months. NFHS-2 also collected data on socioeconomic characteristics of the households, health care and nutrition of women. The covariates for the present study are ethnicity, religion and sectors such as rural/urban residence, mother's educational status and mother's nutritional status through BMI and standard of living index.

Here the representative number of children is 26,369 of ages between 0 and 35 months. It is possible to compute *Z*-scores of the three nutritional indices weight-for-age, height-for-age and weight-for-height. A *Z*-score of -2 was used as a cut-off point for estimation of status of malnutrition of children. The *Z*-score is defined as the deviation of the value observed for an individual from the median of the reference population, divided by the standard deviation (SD) of the reference population. In fact the values of the *Z*-scores have been taken as supplied by IIPS. They took the reference population as that given in the National Center for Health Statistics (2000) and WHO international reference population (IIPS & ORC Macro, 2000, p. 265). Mother's BMI was computed by using the formula weight/height^2 (kg/m^2). A BMI of less than 18·5 indicates chronic energy deficiency or undernutrition (WHO, 2000).

The weight-for-height (WHZ) index is an indicator of thinness or wasting. Wasting is short-term malnutrition due to acute starvation or severe disease, famine etc., but it may result also from chronic dietary deficiency or disease. Height-for-age (HAZ) is an indicator of stunting, which can result from chronic malnutrition, but genetic factors are also related to it. The third index, weight-for-age (WAZ), is primarily a composite index of HAZ and WHZ, i.e. an indicator of both acute and chronic malnutrition. In young children, low weight-for-age reflects low weight-for-height, but in the later period it reflects low height-for-age.

To assess the sex differences of undernutrition of children, percentages of malnourished boys and girls according to weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) were obtained for each of the 26 states in India. Moreover, the averages give an indication of the overall nutritional situation of the children of the states. An average value of zero means that the state is similar to the reference category and is balanced, whereas a mean value of less than zero shows a poor health status. A high positive average value shows a prevalence of over-nourished children in the state. To see if there is a relation between the degree of

malnutrition and the age of children the status of malnutrition can be directly regressed on age taking quadratic form of age separately for boys and girls. After removing the effect of age, it can then be seen whether nutritional status depends on the socio-demographic variables by regression analysis. It is also possible to see whether there is any sex or rural–urban difference before and after removing the effect of age and socio-demographic variables, including standard of living index (SLI) of the household. The mean values of the *Z*-scores separately for each combination of male–female and rural–urban regions may be used for this purpose. (Note: The SLI reflects the economic well-being of the household. In this paper a number of variables are taken to arrive at the index. Each variable is given a score according to the degree of severity of the values of the variables and the sum of these scores is calculated. The SLI of the household can then be defined from the total score obtained by the household. In this paper the SLI is defined as being low (i.e. SLI=1) if the total score is in the interval 0–14, otherwise SLI is high (i.e. SLI=0).)

Results

State-wise mean values of the *Z*-scores of the children of age 0–35 months by sex are shown in Table 1. Bihar, Madhya Pradesh and Orissa are the only three states in India where the average *Z*-scores for WAZ and HAZ show values close to − 2 or less, which means, assuming a symmetric distribution, about 50% or more children are malnourished. Thus these three states are the most affected states in India. In fact the actual percentages of malnourished children according to WAZ are 53·8%, 53·6% and 53·4% for boys and 57·0%, 57·0% and 53·9% for girls, respectively, for Bihar, Madhya Pradesh and Orissa. Other *Z*-scores also show similar results (see Tables 2, 3 and 4). The gender differences of the mean scores have a striking feature. The developed states and the north-east states have higher mean values for girls, showing a better health status of female children. Most of the north-east states are inhabited by tribal populations. These are mainly Christians and enlightened. Part of the geographical and gender heterogeneity may be due to real differences between states, but may be confounded by socio-demographic and economic differences. To assess this, the effect of age must be eliminated from the *Z*-scores.

When age-wise 'average Z-scores' are plotted, it shows a non-linear trend (not shown here). The Z-scores first decrease and then show an increasing trend. Thus the Z-scores are not independent of age as one would expect. Moreover, the dependency is not linear. The feature – that the nutritional level of children falls at the beginning and then rises afterwards – clearly shows that it is appropriate to take a quadratic form of age to eliminate the effect of age from the Z-scores.

In India 45·0% of girls and 43·0% of boys are underweight (Table 2). The percentage of underweight girls is slightly more than the percentage of underweight boys. But there are considerable variations in these percentages over the states. The percentage of underweight girls varies from 20·2% (in Goa) to 57·0% (in Bihar and Madhya Pradesh), whereas these percentages among boys are 20·0% (in Sikkim) and 53·8% (in Bihar). Bihar is thus the most affected state. The states with high percentages of underweight children, besides Bihar, are Gujarat (girls, 52·1%; boys, 41·5%), Madhya Pradesh (girls, 57·0%; boys, 53·6%), Orissa (girls, 53·9%; boys,

Table 1. State-wise means and standard deviations (SD) of WAZ, HAZ and WHZ of 0–35 month children by sex

	WAZ				HAZ				WHZ					
	Boys		Girls		Boys		Girls		Boys		Girls		Total (*N*)	
States	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Boys	Girls
Andhra Pradesh	−1·49	1·36	−1·65	1·31	−1·59	1·75	−1·73	1·62	−0·55	1·59	−0·60	1·53	486	490
Assam	−1·08	1·97	−1·13	2·02	−2·62	2·66	−2·31	2·93	1·38	3·59	0·92	3·25	405	356
Bihar	−2·05	1·64	−2·07	1·77	−2·36	2·59	−2·21	2·61	−0·53	2·81	−0·68	2·34	1243	1158
Goa	−1·41	1·15	−1·28	1·00	−1·04	1·39	−0·81	1·20	−0·94	1·16	−0·82	1·00	171	130
Gujarat	−1·70	1·41	−1·89	1·50	−1·80	1·94	−1·79	2·06	−0·64	1·72	−0·81	1·56	561	539
Harayana	−1·41	1·36	−1·57	1·45	−1·98	1·98	−2·10	1·93	−0·01	1·88	−0·03	1·85	516	416
HP	−1·70	1·28	−1·60	1·29	−1·75	1·83	−1·43	1·80	−0·60	2·08	−0·74	1·59	438	374
J & K	−1·46	1·34	−1·32	1·40	−1·83	2·31	−1·58	2·05	−0·13	2·73	−0·19	2·13	477	387
Karnataka	−1·75	1·34	−1·77	1·44	−1·51	1·75	−1·48	1·78	−1·00	2·00	−1·02	1·45	546	520
Kerala	−1·41	1·08	−1·15	1·21	−1·33	1·81	−1·05	1·71	−0·45	2·70	−0·45	1·77	310	289
MP	−2·03	1·48	−2·10	1·63	−2·10	2·31	−2·13	2·27	−0·74	2·47	−0·84	2·08	1217	1170
Maharastra	−1·87	1·28	−1·75	1·35	−1·52	1·49	−1·51	1·55	−1·15	1·37	−1·00	1·30	782	719
Manipur	−1·28	1·24	−1·17	1·36	−1·39	1·49	−1·32	1·43	−0·44	1·31	−0·29	1·41	305	288
Meghalaya	−1·52	1·62	−1·39	1·66	−1·78	1·88	−1·64	2·00	−0·46	1·53	−0·22	2·30	212	209
Mizoram	−1·19	1·40	−0·93	1·56	−1·40	1·80	−1·03	1·81	−0·31	1·71	−0·29	1·53	232	199
Nagaland	−1·15	1·97	−1·02	1·46	−1·17	1·92	−1·07	1·85	−0·47	1·73	−0·29	1·94	182	203
Orissa	−1·99	1·35	−1·99	1·34	−1·68	1·65	−1·68	1·81	−1·21	1·39	−1·13	1·62	691	621
Punjab	−1·17	1·31	−1·29	1·47	−1·59	1·89	−1·82	1·95	−0·03	1·91	0·10	1·99	411	374
Rajasthan	−1·94	1·44	−1·91	1·61	−2·13	1·94	−2·10	2·05	−0·70	1·65	−0·66	1·73	1286	1179
Sikkim	−0·98	1·33	−1·04	1·31	−1·18	2·08	−1·31	1·68	−0·15	1·61	−0·11	1·55	190	181
Tamil Nadu	−1·54	1·33	−1·46	1·51	−1·40	1·89	−1·21	2·07	−0·71	1·87	−0·74	2·02	636	570
West Bengal	−1·71	1·18	−1·82	1·41	−1·61	1·46	−1·82	1·69	−0·80	1·52	−0·75	1·44	553	504
Uttar Pradesh	−1·86	1·40	−2·00	1·59	−2·12	2·01	−2·28	2·02	−0·57	1·73	−0·62	1·58	1243	1128
New Delhi	−1·50	1·54	−1·30	1·84	−1·66	2·39	−1·56	2·27	−0·28	3·10	−0·20	2·84	372	273
ARP	−1·17	1·47	−1·03	1·42	−0·83	2·02	−0·86	2·13	−0·64	2·47	−0·43	1·77	192	178
Tripura	−1·83	1·33	−1·51	1·68	−1·92	2·54	−1·39	2·70	−0·61	1·91	−0·66	2·18	127	130
All India	**−1·70**	**1·45**	**−1·70**	**1·57**	**−1·82**	**2·05**	**−1·79**	**2·08**	**−0·56**	**2·14**	**−0·59**	**1·92**	**13,784**	**12,585**

HP, Himachal Pradesh; J & K, Jammu & Kashmir; MP, Madhya Pradesh; ARP, Arunachal Pradesh.

Table 2. State-wise distribution of nutritional index through weight-for-age among 0–35 month children in India by sex

	Boys			Girls		
State	*N*	% underweight (< −2SD)	% overweight (≥ +2SD)	*N*	% underweight (< −2SD)	% overweight (≥ +2SD)
Andhra Pradesh	486	35·2	1·2	490	40·2	1·0
Assam	405	34·1	8·6	356	35·7	7·9
Bihar	1243	53·8	1·9	1158	57·0	2·4
Goa	171	33·3	1·2	130	23·1	0·0
Gujarat	561	41·5	0·9	539	52·1	1·3
Haryana	516	32·2	1·4	416	40·6	1·9
Himachal Pradesh	438	41·8	0·9	374	41·2	0·8
Jammu & Kashmir	477	35·4	0·8	387	32·8	1·3
Karnataka	546	43·8	0·5	520	46·9	1·3
Kerala	310	27·4	0·3	289	23·5	1·7
Madhya Pradesh	1217	53·6	1·2	1170	57·0	1·2
Maharastra	782	47·8	0·9	719	47·3	1·4
Manipur	305	26·9	0·7	288	30·9	2·4
Meghalaya	212	36·8	2·4	209	37·8	3·3
Mizoram	232	27·2	1·7	199	24·1	3·5
Nagaland	182	29·7	4·4	203	20·2	3·9
Orissa	691	53·4	1·0	621	53·9	1·0
Punjab	411	27·5	1·5	374	31·0	2·1
Rajasthan	1286	50·7	0·8	1179	51·7	1·4
Sikkim	190	20·0	2·6	181	22·7	1·7
Tamil Nadu	636	36·2	0·8	570	37·9	2·3
West Bengal	553	43·4	0·4	504	47·6	1·2
Uttar Pradesh	1243	49·8	1·3	1128	53·3	1·6
New Delhi	372	37·4	2·4	273	34·1	2·9
Arunachal Pradesh	192	28·1	2·6	178	23·6	3·4
Tripura	127	43·3	0·8	130	40·0	3·1
India	**13,784**	**43·0**	**1·4**	**12,585**	**45·0**	**1·9**

53·4%), Rajasthan (girls, 51·7%; boys, 50·7%) and Uttar Pradesh (girls, 53·3%; boys, 49·8%). The states with low percentages of underweight children are Goa (girls, 23·1%; boys, 33·3%), Kerala (girls, 23·5%; boys, 27·4%) and Punjab (girls, 31·0%; boys, 27·5%), which are the three most developed states in India; Manipur (girls, 30·9%; boys, 26·9%), Mizoram (girls, 24·1%; boys, 27·2%), Nagaland (girls, 20·2%; boys, 29·7%), Sikkim (girls, 22·7%; boys, 20·0%) and Arunachal Pradesh (girls, 23·6%; boys, 28·1%), which are the north-eastern states. The north-eastern states have a high educational level for both males and females. One can also notice that the percentages of underweight girls are less than the percentages of underweight boys in these states, i.e. where the percentages of affected children are low.

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Table 3. State-wise distribution of nutritional index through height-for-age among 0–35 month children in India by sex

State	Boys			Girls		
	N	Stunted (< − 2SD)	Tall (≥ +2SD)	*N*	Stunted (< − 2SD)	Tall (≥ +2SD)
Andhra Pradesh	486	37·9	2·7	490	38·6	1·0
Assam	405	56·8	4·4	356	56·2	8·7
Bihar	1243	55·3	4·1	1158	54·7	4·7
Goa	171	24·0	1·8	130	10·8	2·3
Gujarat	561	44·4	2·5	539	45·8	3·9
Hariyana	516	48·4	2·1	416	55·5	2·4
Himachal Pradesh	438	44·7	2·5	374	35·0	3·5
Jammu & Kashmir	477	42·1	3·4	387	39·8	3·4
Karnataka	546	35·0	1·8	520	38·5	2·1
Kerala	310	24·2	0·6	289	22·1	3·1
Madhya Pradesh	1217	50·5	3·1	1170	52·6	3·7
Maharastra	782	35·3	1·4	719	38·8	1·5
Manipur	305	33·4	1·6	288	31·3	1·0
Meghalaya	212	45·3	3·8	209	43·5	4·3
Mizoram	232	37·1	3·9	199	29·6	4·5
Nagaland	182	39·6	7·1	203	27·6	4·9
Orissa	691	43·8	1·6	621	43·3	2·3
Punjab	411	39·2	2·4	374	40·1	1·1
Rajasthan	1286	50·7	1·8	1179	53·7	3·1
Sikkim	190	32·1	2·6	181	31·5	3·3
Tamil Nadu	636	33·8	2·2	570	30·7	4·6
West Bengal	553	34·9	0·7	504	43·1	1·4
Uttar Pradesh	1243	52·9	2·3	1128	56·4	2·1
New Delhi	372	39·0	4·0	273	39·9	6·2
Arunachal Pradesh	192	25·5	8·9	178	26·4	9·6
Tripura	127	48·8	3·9	130	35·4	4·6
India	**13,784**	**43·9**	**2·6**	**12,585**	**44·4**	**3·3**

When the percentages of stunted children are compared the picture is similar (Table 3). However, Assam and Haryana come into the list of high-percentage states. Orissa and Gujarat are not so severely affected. Punjab, though a developed state, can no longer be counted as a less-affected state. Most of the north-east states have higher percentages than expected. It seems that stunting of children is not just determined by the literacy status of the parents. It has other dimensions also. Altitude and possibly temperature should also be taken into consideration. The gender discrepancy in these states is similar to the case of weight-for-age.

Since the general level of height is relatively low in India, the weight-for-heights have high values for most of the children (Table 4). As a result, the percentage of wasted children is less than 20% for most of the states. Thus it is very difficult to

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Table 4. State-wise distribution of nutritional index through weight-for-height among 0–35 month children in India by sex

State	Boys			Girls		
	N	Wasted (< − 2SD)	Overweight (≥ +2SD)	*N*	Wasted (< − 2SD)	Overweight (≥ +2SD)
Andhra Pradesh	486	10·9	4·3	490	8·8	4·9
Assam	405	12·8	36·5	356	13·8	31·7
Bihar	1243	23·2	10·1	1158	22·8	8·8
Goa	171	14·0	2·3	130	13·1	—
Gujarat	561	15·0	5·9	539	18·9	4·8
Haryana	516	7·2	8·5	416	5·0	9·6
Himachal Pradesh	438	17·4	5·3	374	16·8	4·3
Jammu & Kashmir	477	13·2	9·4	387	9·6	8·8
Karnataka	546	23·4	3·3	520	19·0	3·3
Kerala	310	11·9	5·8	289	9·7	3·8
Madhya Pradesh	1217	21·1	6·1	1170	20·3	5·7
Maharastra	782	21·6	1·9	719	18·6	1·4
Manipur	305	9·2	3·3	288	6·9	6·9
Meghalaya	212	14·2	5·7	209	16·3	12·4
Mizoram	232	12·9	6·5	199	9·5	8·0
Nagaland	182	14·3	8·2	203	11·3	7·9
Orissa	691	26·9	2·2	621	24·5	1·4
Punjab	411	10·0	8·0	374	5·3	9·6
Rajasthan	1286	14·8	3·5	1179	13·8	4·2
Sikkim	190	7·4	7·4	181	6·1	9·4
Tamil Nadu	636	19·7	5·2	570	17·5	6·1
West Bengal	553	14·5	4·0	504	12·5	3·2
Uttar Pradesh	1243	12·0	4·7	1128	11·4	3·4
New Delhi	372	16·4	8·9	273	13·2	7·0
Arunachal Pradesh	192	14·1	4·2	178	9·0	5·6
Tripura	127	15·7	7·1	130	19·2	9·2
India	**13,784**	**16·5**	**6·5**	**12,585**	**15·1**	**6·2**

compare the states, as variation in the percentages is not great. The states that have less than 10% wasted children for both boys and girls are Haryana, Manipur and Sikkim, and the states with more than 20% wasted children for both boys and girls are Bihar, Madhya Pradesh and Orissa. Thus these three states are the most affected states in all respects and need greater attention.

To see the intervening variables of the three *Z*-scores, a logistic regression was performed on each of the three *Z*-scores of the children for caste, religion, mother's literacy and BMI status, and SLI of the households (Table 5). All the variables have profound effects on weight-for-age and height-for-age, but mother's literacy level does not have a significant effect on weight-for-height (WHZ). As doubts have already been raised about the efficacy of WHZ as an indicator or the status of malnutrition

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Table 5. Result of regression of *Z*-scores on socio-demographic variables after removing the effect of age

	Dependent variable					
Independent variables	WAZ (Male)	HAZ (Male)	WHZ (Male)	WAZ (Female)	HAZ (Female)	WHZ (Female)
SC/ST/OBC	− 0·159	− 0·164	− 0·086	− 0·201	− 0·092	− 0·141
	(0·000)	(0·000)	(0·025)	(0·000)	(0·012)	(0·000)
Hindu/Muslim	− 0·366	− 0·397	− 0·131	− 0·409	− 0·324	− 0·315
	(0·000)	(0·000)	(0·023)	(0·000)	(0·000)	(0·000)
Mother's illiteracy	− 0·359	− 0·505	− 0·060	− 0·350	− 0·485	− 0·026
	(0·000)	(0·000)	(0·130)	(0·000)	(0·000)	(0·481)
BMI	0·081	0·052	0·077	0·084	0·046	0·079
	(0·000)	(0·000)	(0·000)	(0·000)	(0·000)	(0·000)
SLI	− 0·223	− 0·238	− 0·119	− 0·237	− 0·210	− 0·113
	(0·000)	(0·000)	(0·005)	(0·000)	(0·000)	(0·004)
R^2	0·102	0·050	0·016	0·055	0·040	0·025
F (significance)	312·0	144·0	45·9	145·1	104·0	63·9
	(0·000)	(0·000)	(0·000)	(0·000)	(0·000)	(0·000)

Reference categories: General Caste Hindus and other religions; religions other than Hindus and Muslims; literate mothers and high SLI; corresponding to 'SC ST OBC', 'Hindu/Muslim', 'Mother's illiteracy' and 'SLI'. 'BMI' is taken as a continuous variable.

in India, the reason can be traced to the literacy of mothers. The north-eastern states have a high literacy status of both mothers and fathers and that is why WAZ and HAZ values are so high. But mothers' literacy status does not have a significant influence on WHZ and hence north-eastern states cannot be separated out so distinctly.

Whether there are rural–urban differences along with gender differences in the status of malnutrition has also been assessed (Table 6). The rural–urban difference is less in the case of WHZ and more in the cases of WAZ and HAZ. The gender difference is high only for WAZ. The gender differences come almost to nil when the effect of age and the socio-demographic variables are removed from the *Z*-scores. The rural–urban differences also drop substantially but do not become close to zero. This is possibly because only a few variables have been taken. The *Z*-scores depend on many other variables. If all such variables are taken into account then the rural–urban differences will perhaps be close to zero.

Discussion

One of the most important public health problems in India is that of malnutrition in children. This not only obstructs the growth of children, but also has long-term implications. It has a negative impact on future human performance, health and life expectations of children. A recent study estimated that about 53% of all deaths in

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Table 6. Means of WAZ, HAZ and WHZ before and after removing the effect of age, and socio-demographic variables and the rural–urban differences

	Male (M)			Female (F)			Difference (F–M)		
Place of residence	WAZ	HAZ	WHZ	WAZ	HAZ	WHZ	WAZ	HAZ	WHZ
Mean									
Rural (R)	−1·79	−1·95	−0·58	−1·54	−1·83	−0·62	0·24	0·12	−0·04
Urban (U)	−1·45	−1·48	−0·53	−1·24	−1·44	−0·51	0·21	0·04	0·02
Difference (R–U)	−0·34	−0·47	−0·05	−0·31	−0·38	−0·11	0·03	0·09	−0·06
All India	−1·70	−1·82	−0·56	−1·70	−1·79	−0·59	0·00	0·03	−0·03
Adjusted mean[a]									
Rural (R)	−1·71	−1·87	−0·53	−1·72	−1·84	−0·58	−0·01	0·03	−0·05
Urban (U)	−1·66	−1·69	−0·64	−1·65	−1·66	−0·61	0·01	0·03	0·03
Difference (R–U)	−0·05	−0·18	0·11	−0·07	−0·18	0·03	−0·02	0·00	−0·08

The estimated *Z*-scores at the mean values of the regressors were added to the mean of residuals of the respective groups to get the adjusted mean *Z*-scores (Norgan, 1995).
[a]After removing age and socio-demographic variables.

young children are attributable to being underweight (Caulflied *et al*., 2004). Although the majority of underweight children live in developing countries, mainly in Asia and Africa, it has been seen to be increasing in Africa and decreasing in Asia (Ramalingaswami *et al*., 1997). On the basis of 241 national surveys, it has been found that the stunting rates are declining in the majority of countries. Today malnutrition is responsible for nearly 5·2 million annual child deaths in the developing world (WHO, 2002). In India, half of all under-five children suffer from malnutrition and 53% of children are underweight (India Fact File, 2002). According to the Food Insecurity Atlas of Urban India (2002), 38% of Indian children are underweight and 36% are stunted due to poor nutritional intake. In many states of India, including Jharkhand, Orissa, Chattisgarh and Bihar, one-third of children are underweight and half are anaemic (Anon, 2002). The relation between mother's nutrition and their children in less-developed countries has been studied by Scrimshaw *et al*. (1968) and Tomkins & Watson (1989), who found direct relations between the two. An inverse relationship between mother's education and malnutrition of under-five children has been observed (Norhayati *et al*., 1997). Zamaliah *et al*. (1998) found a higher prevalence of stunting, underweight and wasting among under-five children below the poverty line compared with those children above the poverty line. Malnutrition is positively associated with a low duration of breast-feeding (Julia, 2000). It has been reported by many scientists that in India, sex differentials of children's nutritional status and health care are not so marked as intra-household food allocation (Schoenbaum *et al*., 1995; Haddad *et al*., 1996; Mishra *et al*., 1999; Marcoux, 2001). But intra- and inter-state variation is very marked in India due to some social and cultural factors.

In the present study it has been seen that, in India, there is no marked difference in the nutritional status of male and female children in terms of *Z*-score values of

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weight-for-age, height-for-age and weight-for-height. Whatever differences are observed are due to age factors of the children. The children of Bihar, Madhya Pradesh and Orissa are found to be affected most as far as nutritional levels are concerned. High female illiteracy in Bihar, Orissa and Madhya Pradesh seems to be one of the causes for such results. Illiterate mothers are not only less aware of the necessities and ways and means of providing nutritionally balanced food to children, but are also economically incapable of providing such nutrition-rich food (Bharati *et al*., 2007). Women with low BMI status give birth to the maximum number of low birth weight children, which ultimately leads to undernutrition among their children (Pojda & Kelley, 2000). We have in this paper found a significant effect of mother's BMI on children's nutritional status. Besides this, in Bihar, 50% of people are other backward caste (OBC) and in the whole of eastern India, which includes the states of Bihar, West Bengal and Orissa, 30% of people are scheduled caste (SC) (NFHS-II, 2000). The Integrated Child Development Services (ICDS) programme is an important beneficiary programme designed to eradicate undernutrition in India. But Bihar has accommodated only 1·5% of children as its beneficiaries (Gragnolati *et al*., 2005). Comparatively low percentages of undernutrition have been noticed in Kerala, Goa, Mizoram, Nagaland, Manipur, Assam, Punjab, Sikkim and Arunachal Pradesh. In these states also, rural and urban differences are less than in other states of India. General literacy rate as well as female literacy rate is highest and the female sex ratio is higher in Kerala than in other states, which indicates the high status of women in Kerala. The literacy gap between the male and female population is least in Goa, Mizoram and Meghalaya. Manipur, Mizoram, Nagaland and Sikkim have the highest percentages of ICDS beneficiaries in India (Gragnolati *et al*., 2005).

This study's findings suggest that in India there is better nutritional status in urban children than in rural children. This is due to higher maternal education, higher income, better water and sanitation services and better health status of mothers in urban areas. It is expected that educated mothers have a greater knowledge of childcare and feeding practices, which ultimately prevent child malnutrition.

The nutritional status of children born to mother whose BMI is below 18·5 is significantly poor. Maternal malnutrition is one of the major causes of low-birth-weight babies, leading to a high frequency of infant mortality or low levels of child growth. High infant mortality prompts mothers to aspire for more children. This in turn affects the childcare and feeding practices, and thus leads to more stunted, wasted and underweight babies. The standard of living index has a positive impact on the reduction in child malnutrition.

In South Asian countries, including India, the preference for male children is particularly due to social customs such as the dowry, poor social, economic and educational status and lack of decision-making power of women in society. The desire for a male child often results in a large family size. This ultimately leads to a high rate of underweight, stunted and wasted children. Ramalingaswami *et al*. (1997) stated that women in India have a lower status and less decision-making power than those in other developing and developed countries. This limits women's ability to access the resources needed for their child health and nutrition, which are strongly associated with low birth weight as well as poor feeding behaviour in the first year of life.

The geographical variation of level of malnutrition is also found to be very prominent, even after eliminating the effect of age. The rural–urban difference, as well as variation among the different states, diminishes quite substantially when the effect of socioeconomic factors is further eliminated.

From the above discussion, it is clear that a high degree of malnutrition and the geographical disparities in the nutritional level of pre-school children continue to be the two biggest challenges in India. The proposed approaches for increasing the general level of nutrition and amelioration of rural–urban differences in malnutrition of children are to increase the standard of living of households and the general level of health and literacy of mothers. Sanitation and access to safe drinking water, food and nutrition supplementation are not enough as preventive measures for malnutrition in Indian society (Bamji, 2003). So, along with health infrastructure facilities for children and mothers, the status of women should be enhanced by increasing mother's literacy and giving empowerment to mothers in the decision-making process on every aspect of life, including the health care of children.

References

Anon (2002) Malnutrition high in India. In *Deccan Chronicle*, Hyderabad, 7th July.

Bamji, M. S. (2003) Early nutrition and health – Indian perspective. *Current Science* **85**, 1137–1142.

Bharati, S., Pal, M., Bhattacharya, B. N. & Bharati, P. (2007) Prevalence and causes of chronic energy deficiency and obesity of women in India. *Human Biology* **79**, 395–412.

Borooah, V. K. (2005) The height-for-age of Indian children. *Economics and Human Biology* **3**, 45–65.

Caulfied, L., de Onis M., Blossner, M. & Black, R. E. (2004) Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. *American Journal of Clinical Nutrition* **80**, 193–198.

Dasgupta, M., Lokshin, M., Gragnolati, M. & Ivaschenko, O. (2005) *Improving Child Nutrition Outcome in India – Can the Integrated Child Development Services Program be More Effective?* World Bank Policy Research Working Paper No. 3647. World Bank, Washington, DC.

de Onis, M., Blossner, M., Borghi, E., Frongillo, E. A. & Morris, R. (2004) Estimates of global prevalence of childhood underweight in 1990 and 2015. *American Medical Association* **291**, 2600–2606.

Food Insecurity Atlas of Urban India (2002) *Food Insecurity Atlas of Urban India.* M. S. Swaminathan Research Foundation, Chennai, India.

Gorstein, J., Sullivan, K., Yip, R., de Onis, M., Trowbridge, F. & Fajans, P. (1994) Issues in assessment of nutritional status using anthropometry. *Bulletin of the World Health Organization* **72**, 272–283.

Government of India (no date) Program Evaluation Office Study No. 147. Planning Commission, Government of India. URL: http://planningcommission.nic.in/reports/peoreport/cmpdmpeo1/147.pdf.

Gragnolati, M., Shekar, M., Das Gupta, M., Bredenkamp, C. & Lee, Y. K. (2005) *India's Undernourished Children: A Call for Reform and Action.* HNP Discussion Paper. World Bank, Washington, DC.

Haddad, L. J., Pena, C., Nishida, C., Quisumbing, A. & Slack, A. (1996) *Food Security and Nutrition Implications of Intrahousehold Bias: A Review of the Literature*. FCND Discussion Paper No. 19. International Food Policy Research Institute, Washington, DC.

India Fact File (2002) http://www.indianngos.com/factfile.htm (accessed May, 2002).

International Institute for Population Sciences (IIPS) & ORC Macro (2000) *National Family Health Survey* (*NFHS-2*), *1998–99*. IIPS, Mumbai, India.

Jelliffe, D. B. (1966) *Assessment of Nutritional Status of the Community*. Monograph Series No. 53. WHO, Geneva.

Julia, M. (2000) Pattern and determinants of nutritional status in children under two years of age – a cross sectional study in Belu, East Nusa Tenggara, Indonesia. Master Thesis in Public Health, Department of Public Health and Clinical Medicine, Umeo University.

Lloyd-Still, J. D., Hurwitz, I., Wolff, P. H. & Shwachman, H. (1974) Intellectual development after severe malnutrition in infancy. *Pediatrics* **54**, 306–311.

Marcoux, A. (2001) Sex differentials in undernutrition: A look at survey evidence. *Population and Development Review* **28,** 275–284.

Martorell, R. & Ho, T. J. (1984) Malnutrition, morbidity and mortality. *Population and Devolopment Review* (Supplement) **10**, 49–68.

Mishra,V. K., Lahiri, S. & Luther, N. Y. (1999) *Child Nutrition in India*. National Family Health Survey Subject Reports No. 14, June.

National Center for Health Statistics (2000) *Growth Charts: United States.* Advance Data from Vital and Health Statistics, No. 314. National Center for Health Statistics, Hyattsville, MD.

Nawani, N. P. (1994) *Indian Experience on Household Food and Nutrition Security*. FAO-UN, Bangkok, Thailand.

Norgan, N. G. (1995) Body mass index and nutritional status: the effect of adjusting body mass index for the relative sitting height on estimates of the prevalence of chronic energy deficiency, overweight and obesity. *Asia Pacific Journal of Clinical Nutrition* **4**, 137–139.

Norhayati, M., Noorhayati, M. I. & Mohammad, C. G. (1997) Malnutrition and its risk factors among children 1–7 years old in rural Malyasian communities. *Asia Pacific Journal of Clinical Nutrition* **6**, 260–264.

Pojda, J. & Kelley, L. (2000) *Low Birthweight*. ACC/SCN Nutrition Policy Paper 18. WHO, Geneva.

Rajaram, S., Sunil, T. S. & Zoharelli, L. K. (2003) An analysis of childhood malnutrition in Kerala and Goa. *Journal of Biosocial Science* **35**, 335–351.

Ramalingaswami, V., Jonson, U. & Roude, J. (1997) The Asian enigma. In *The Progress of Nations*. UNICEF, New York.

Rao, K. V., Balakrishna, N. & Adinarayanan, K. (1986) Critical limits of some anthropometric measurements and indices for the assessment of nutritional status. *Journal of Nutrition and Dietetic* **23**, 88–89.

Rao, G. R., Ladusingh, L. & Pritamjit, R. (2004) Nutritional status of children in North-East India. *Asia Pacific Population Journal* **19**, 39–56.

Schoenbaum, M., Tulchinsky, T. H. & Abed, Y. (1995) Gender differences in nutritional status and feeding patterns among infants in the Gaza Strip. *American Journal of Public Health* **85**, 965–969.

Scrimshaw, N. S., Taylor, C. & Gordon, J. E. (1968) *Interactions of Nutrition and Infection*. WHO, Geneva.

Smith, L. & Haddad, L. (2000) *Overcoming Child Malnutrition in Developing Countries: Past Achievement and Future Choices.* International Food Policy Research Institute, Washington, DC.

Tomkins, A. M. & Watson, F. E. (1989) *Malnutrition and Infection: A Review*. WHO, Geneva.

UNICEF (1994) *The Progress of Nations*. UNICEF, New York.

UNICEF (2001) *The State of the World's Children*. UNICEF, New York.

World Health Organization (1995) *Physical Status: The Use and Interpretation of Anthropometry*. WHO Technical Report Series No. 854. WHO, Geneva.

World Health Organization (1997) *WHO Global Database on Child Growth and Malnutrition*. Document No. WHO/NUT/97·4. WHO, Geneva.

World Health Organization (2000) *Obesity: Preventing and Managing the Global Epidemic*. Report of a WHO Consultation. WHO Technical Report Series No. 894. WHO, Geneva.

World Health Organization (2002) http://www.who.int/nut/nutrition2.htm.

Zamaliah, M. M., Mohd Nasir, M. T., Khor, G. L. & Tee, E. S. (1998) Socio-economic determinants of nutritional status of children in rural peninsular Malaysia. *Asia Pacific Journal of Clinical Nutrition* **7**, 307–310.