Growth and nutritional status of preschool children in India: A study of two recent time periods

Pronab Sen, Susmita Bharati, Suparna Som, Manoranjan Pal, and Premananda Bharati

Abstract

Background*. Preschool children call for focused attention in India because India has the highest percentage of undernourished children in the world.*

Objective. *To compare the growth and nutritional status of Indian preschool children for the periods 1998/99 and 2005/06,*

Subjects and methods. *Using data on weight and length/height as well as the sociodemographic background of preschool children from the National Family Health Surveys (NFHS) from 1998/99 and 2005/06, we determined the distribution of weight and length/height and their association with sociodemographic variables.*

Results. *The distributions of weight and length/height around the mean remained remarkably stable over age but were much greater in India than the international norms. The rates of growth of mean weight and length/height were far lower in India than the international norms up to the age of 2 years. The temporal trend indicates declines in the percentages of undernourished (low weight-for-age) and stunted (low height-for-age) children over the 7-year period, although the degree of improvement was far better for stunting than for underweight. Mother's educational status is the only variable that has been found to influence child nutrition.*

Conclusion. *The level of mothers' education needs urgent attention with top priority to reduce the prevalence of underweight and stunting of children. This also implies that, for future benefit, girls should be given more facilities for better education. Breastfeeding and weaning practices also need special attention.*

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Introduction

Although the term "malnutrition" refers to both under- and overnutrition, it is undernutrition which has dominated discussions on malnutrition in India. Numerous studies have documented a high incidence of undernourished children in India against international benchmarks [1–5]. In fact, India has the highest percentage of undernourished children of all countries in the world. Preschool children, in particular, call for focused attention because this age group not only has special needs, but also forms the platform for growth and development of all children. Undernutrition among preschool children is the result of a complex interplay of diverse elements, such as birthweight, household access to food, availability and use of drinking water, sanitation, child and maternal care, etc.

About 30% of children in India are born with low birthweight [6]. Undernutrition during pregnancy is identified as one of the major causes of low birthweight, because underweight women are likely to give birth to low-birthweight babies [7, 8]. Apart from poverty, which is responsible for maternal undernutrition, some sociocultural factors, such as early marriage of women, adolescent pregnancy, beliefs, and taboos, also seem to be responsible for low-birthweight babies [5]. Undernutrition has a pronounced retarding effect on growth and development and often may result in growth failure and permanent impairment of the body [9].

In the early 1990s, about half of preschool children in India were deemed to be malnourished, irrespective of whether malnourishment was measured by stunting or underweight. During the same period, several other countries in South Asia and sub-Saharan Africa had similar levels of child malnutrition. The prevalence rates of stunted and underweight children in India have declined since then, but at a slower pace than in most other developing countries [10, 11].

Since independence in 1947, there have been significant developments in the fields of agriculture and education, advances in technology, and growth in the economy, yet nearly 50% of children in India still remain undernourished [12–15]. In fact, weight-for-height performance has declined during the period from National Family Health Survey (NFHS)-2 (1998/99) to and NFHS-3 (2005/06), as documented by Deaton and Dreze [15] and Maitra et al. [16]. Also, as found by Maitra in 2010, one in every three children under three years of age (0–35 months) is undernourished in India [16]. Currently, the GDP growth rate is more than 8% [6]. As a result, compared to 1998/99, the poverty rate has decreased by 50% during 2004-05, most of the decrease occurring in urban areas [17, 18]. During the same period, mortality and fertility rates have decreased by 50% and 40%, respectively [6]. The rate of undernutrition has also decreased, but not as rapidly as the mortality and fertility rates; the rate of undernutrition among children of less than 5 years has decreased by only 20% during the period 1992–93 to 2005–06 [6]. Two national-level studies found that the rate of undernutrition among preschool children fell by 11% between 1992/93 and 1998/99 [4]. Over the past three decades, the proportion of household expenditure on food items has decreased, partly due to the decrease in relative prices of food grains and the increase in access to subsidized food grains [6]; however, questions about adequacy—as far as food consumption is concerned—still remain. Another possible factor is unequal intrahousehold food distribution within the family, which has an adverse effect on preschool children [19]. It has also been argued that some socioeconomic factors, such as gender, place of residence, parents' (particularly the mother's) educational status, religion, and caste, have a significant impact on the rate of undernutrition among children [4, 20–22]. There is also substantial interstate variation in the pattern and trends of undernutrition.

The objectives of this study were to re-examine in detail the anthropometric measures of preschool (0 to 35 months) children in India with the use of NFHS-2 and NFHS-3 data; to study the changes in growth and undernutrition of these children between 1998/99 and 2005/06 in relation to state and to rural versus urban residence; to determine the cross-sectional and temporal impacts of different socioeconomic variables on undernutrition; and to find the key variables that can explain preschool undernutrition in this society.

Materials and methods

Most of the existing literature on the nutritional status of children in India tends to deal with age groups at the aggregate level, such as preschool, school-age, adolescence, etc. Although this study broadly has preschool children, i.e., those in the age group from 0 to 35 months, as its focal point, we believe that aggregative measures mask more than they reveal. This is especially true of this particular age group, since factors affecting the nutritional outcome measures vary substantially during different stages of infancy and early childhood. Maternal health, breastfeeding practices, weaning practices, and solid diet patterns each play a dominant role in different stages of the early life cycle. An understanding of the possible impact of such factors can only be obtained through a more disaggregated analysis, in which the pattern of development is traced for relevant age groups.

Data source

Comparable data were obtained from the two National Family Health Surveys (NFHS) conducted in 1998/99 and 2005/06 [12, 13]. Both the surveys were coordinated by the International Institute for Population Sciences (IIPS). The NFHS-3 (2005/06) sample covers the Indian population living in 29 states, and the population frame was based on the 2001 census, whereas NFHS-2 (1998/99) covers only 26 states with the population frame of the 1991 census. The age group of the children in our study was 0 to 3 years. The sample sizes were 21,252 and 24,888 for NFHS-3 and NFHS-2, respectively. The anthropometric response variables were weight and length/height of the child. The independent variables were sex of the child; type of residence; religion; mother's educational, occupational, and nutritional status; household standard of living index; and mother's decision-making power. The nutritional status of the mother was determined by her body mass index (BMI), and her decision-making power by her control over the expenditure of her own earnings.

The sample sizes in this study differ from the actual sample sizes of NFHS-2 and NFHS-3. This was done to maintain the parity of nutritional outcome data with some selected socioeconomic variables. We have tried to ensure that the data of the variables are available in both surveys, and that there are no outlying observations for these variables.* We considered only the youngest child in the age group from 0 to 35 months at the last birthday for both surveys. This is due to the fact that the IAKR files from both NFHS-2 and NFHS-3 only contain information on the youngest child. Nevertheless, the sample sizes are more than adequate for the purpose.

* Outlying observations are those with improbable heights/lengths or weights, i.e., less than a given value or more than a given value. The numbers of observations lost due to this are too small to affect any result.

Methods

The length of children under 2 years of age was measured with the child in a lying position; for children 2 years of age, the height was measured with the child in a standing position. Length or height was measured with an adjustable wooden measuring board specifically designed to provide accurate measurements (to the nearest 0.1 cm) in a field situation [12, 13]. The children were weighed with a solar-powered digital scale with an accuracy of ± 100 g [12, 13]. Age was verified from the record of date of birth and was recorded in the schedule as day, month, and year.

To standardize techniques for the collection of data on weight and length/height, the field staff were trained in training of trainers workshops organized by the International Institute for Population Sciences and in addition were trained subsequently in each state according to the standard procedures discussed in the training of trainers workshops. The health investigators who were involved in taking anthropometric measurements received additional special training in the classroom and extensive field practice in schools, *anganwadi** and communities.

The means and standard deviations of weight and length/height of children 0 to 35 months of age were calculated for the six groups 0 to 2, 3 to 5, 6 to 8, 9 to 11, 12 to 23, and 24 to 35 months. The changes in the means between the two survey periods were calculated,** and the significance of the changes was determined by the *t*-test according to age group, state, and socioeconomic variables. Positive changes in weight or length/height and negative changes in indices of malnutrition indicate improvement between the two surveys.

To determine the temporal trend of undernutrition with different socioeconomic variables, linear regression analysis was also done. For this analysis, the state-wise distribution of percentage differences in the prevalence of low nutritional status, such as underweight and stunting, between the two time periods was considered a dependent variable. The percentage differences of superior categories of each socioeconomic variable in respect of India as well as its states were independent variables. These variables are female sex, urban residence, Christian or other religious group, literate mother, working mother, mother's body mass index (BMI) in normal or above category, and high household standard of living. In this analysis, mothers' decision-making power over spending their own earnings has not been considered because of the small sample size. Differences between the two time periods are considered for only 26 states, because during NFHS-2 data collection the number of states was 26. SPSS, version 12.0, was used for all analyses. Levels of significance of $p < .01$, .05, and 0.1 were considered.

Results

On means and dispersions

Data on children's weight and length/height are shown in **table 1**. There were positive changes between the two time periods in weight and length/height in all age groups, although the magnitudes are not particularly large, except in the 24- to 35-month group. In the aggregate, for the preschool age group from 0 to 35 months, the change is roughly of the same order of magnitude for both length/height and weight. The percentage changes in both length/height and weight are U-shaped as the age group increases. The results of the *t*-test, however, indicate that in the case of weight there is not much difference in the means between 1998/99 and 2005/06 for the age groups up to 9 months, and the difference becomes significant only from 12 months onwards; for length/height, on the other hand, the difference is highly significant from the earliest age and increases with increasing age. The data suggest that real progress has been achieved mainly in the higher age brackets, particularly in the length/height indicator. At a superficial level, the data in **table 1** appear to substantiate this finding, since the standard deviations for both weight and length/height increase more or less consistently with age.

However, it needs to be noted that the standard deviation is not the appropriate statistical measure for this purpose, since it is a measure of absolute dispersion and should not be used to compare distributions when the means are significantly different. For a proper comparison, it is necessary to examine the behavior of a measure of relative dispersion, and the coefficient of variation (CV; the standard deviation divided by the mean) is possibly the most suitable statistic for this purpose. The CVs for both weight and length/height across the age groups in the two surveys were computed and are shown in **table 2**.

The CVs shown in **table 2** are quite remarkable and display at least two startling features. First, there is no evidence whatsoever of increasing dispersion with age either for weight or for length/height. The CVs are roughly constant, or even mildly declining, with age

* *Anganwadi* are government-sponsored childcare and mothercare centers throughout India that cater to children in the 0-6 age group. The word means "courtyard shelter" in Hindi. *Anganwadi* were started by the Indian government in 1975 as part of the Integrated Child Development Services program to combat child hunger and malnutrition.

** To find the proportional changes in the mean values of heights and weights as well as of health status through weight-for-age and height-for-age measures, the value for the 1998/99 time period was first subtracted from the corresponding value for the 2005/06 time period for each variable and then divided by the value for the 1998/99 time period. Percentages were obtained by multiplying the proportional values by 100.

TABLE 1. Mean weight and length/height of 0- to 35-month-old children and percentage change in means between 1998/99 and 2005/06 for all India

Age (mo)	1998/99			2005/06			*t* for difference in means	% change in mean
	n	Mean	SD	*n*	Mean	SD		
Weight (kg)								
0–2	1,669	4.24	0.98	1,191	4.30	1.00	1.59	1.42
3–5	2,476	5.73	1.20	2,049	5.80	1.12	2.02	1.22
6–8	2,312	6.82	1.23	2,203	6.89	1.22	1.91	1.05
9–11	1,910	7.49	1.28	1,970	7.58	1.23	2.23	1.20
12–23	8,305	8.62	1.51	7,705	8.79	1.44	7.52	1.97
24–35	8,216	10.40	1.75	6,134	10.59	1.70	6.55	1.83
All ages	24,888	8.37	2.40	2,1252	8.46	2.32	4.50	1.08
Length/height (cm)								
0–2	1,669	54.98	3.75	1,191	55.73	3.94	5.14	1.36
3–5	2,476	60.96	4.17	2,049	61.83	4.14	7.01	1.43
6–8	2,312	65.56	4.06	2,203	66.38	4.20	6.72	1.25
9–11	1,910	68.84	4.23	1,970	69.63	4.13	6.07	1.15
12–23	8,305	74.20	5.26	7,705	75.20	5.09	12.19	1.35
24–35	8,216	81.92	5.99	6,134	83.91	5.93	19.78	2.43
All ages	24,888	72.93	9.80	21,252	73.90	9.75	10.66	1.33

for both weight and length/height in both the surveys

Second, and perhaps more surprisingly, the CVs for each of the anthropometric measures, i.e., weight and length/height, are virtually identical across all age groups as well as in both survey periods. This constancy over age groups and over time is most unexpected, especially in a country as genetically, socially, and economically diverse as India. It may, therefore, be instructive to compare the results reported above with the World Health Organization (WHO) standards, which are used as the universal benchmarks for assessing child health and malnutrition [11]. This comparison is shown in **table 3**.

The first point to note in **table 3** is that the models used by WHO yield very stable relative distributions across the relevant age groups, as evidenced by the stable CVs. The behavior of the CVs of the WHO standards and of those in India shows similar patterns, although there are significant differences in the magnitudes. In particular, the Indian data also demonstrate the same interage group distributional stability that is inherent in the WHO standards.

The WHO standards reported in **table 3** were derived by aggregating the monthly agewise standards for means and standard deviations reported separately for girls and boys by WHO in order to correspond with the class intervals used in this paper. For weighting girls and boys, sample proportions of 47.5% and 52.5% have been used. There is of course a problem in computing the standard deviations, and hence the CVs, for weight, since the model used by WHO yields varying standard deviations for levels for each age group.

TABLE 2. Coefficient of variation in weight and length/height of 0- to 35-month-old children across age groups in 1998/99 and 2005/06

Age (mo)	1998/99		2005/06	
	Weight	Length/height	Weight	Length/height
0–2	0.23	0.07	0.23	0.07
3–5	0.21	0.07	0.19	0.07
6–8	0.18	0.06	0.18	0.06
9–11	0.17	0.06	0.16	0.06
12–23	0.18	0.07	0.16	0.07
24–35	0.17	0.07	0.16	0.07

Keeping the above points in mind, it may be seen from **table 3** that there is virtually no difference between India and the WHO standards in mean weight for the lowest age group, and that the mean length/height of children in the lowest age group in India is greater than the WHO standard. The real difference occurs in the dispersions, where the CV for India is 67% higher for weight and 75% higher for length/height than the WHO standards. In the higher age groups, significant and increasing differences appear in all the mean values, while the relative position of the CVs remains more or less constant, with perhaps a mildly declining trend for the higher age groups in the case of weight. Although the differences in the means can reasonably be ascribed to nutritional and other

TABLE 3. Comparison of WHO standards and Indian data for weight and length/height of 0- to 35-month-old children according to age group[a]

Age (mo)	Weight (kg)				Length/height (cm)			
	WHO		India		WHO		India	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
0–2	4.4	0.14	4.3	0.23	54.2	0.04	55.7	0.07
3–5	6.7	0.12	5.8	0.19	63.0	0.03	61.8	0.07
6–8	8.0	0.11	6.9	0.18	68.2	0.03	66.4	0.06
9–11	8.9	0.11	7.6	0.16	72.4	0.03	69.9	0.06
12–23	10.6	0.12	8.8	0.16	81.5	0.03	75.2	0.07
24–35	12.8	0.12	10.6	0.16	90.6	0.04	83.9	0.07

a. WHO standards are from World Health Organization [11]. CV, coeffiecient of variation

environmental factors, the stability of the distribution across age groups, as evidenced by the CVs, cannot. Indian children who are born and raised abroad have growth performances very close to the international growth standards. This again points to the importance of nutrition and environment in explaining the very high degree of child undernutrition in India [23–25].

It may perhaps be argued that the stability of the distribution is the outcome of a fortuitous choice of samples in the two surveys. This, however, is not the case. In order to demonstrate this, albeit obliquely, **table 4** shows the percentage changes in length/height and weight for each age group according to place of residence (rural or urban). There is no evidence of consistency in the samples. This is not surprising, because the two surveys were done independently, although the procedures were more or less same. The samples are different. The maximum changes occur in urban children in lower age groups. On the other hand, the mean weight in the age group from 0 to 2 months remains completely stagnant during this period in rural areas. Given any age group, urban and rural difference in the year 1998/99 is not much different from that of 2005/06 for both weight and length/height. Residential differences do not show any prominent change in mean length/height and weight with increasing age. A jump is observed in length/height measurements only in the age group from 24 to 35 months for both rural and urban areas. Mean length/height and weight measurements are lower in rural than in urban areas for every age group.

It, therefore, appears reasonable to accept three fundamental characteristics of the Indian experience that have been revealed by the survey data:

» The dispersions of both weight and length/height of children in India are extremely high as compared with international standards;
» The mean weight and length/height of children in India increase much more slowly with age as compared with international standards;
» The relative distributions around the means remain more or less stable over age groups.

These three characteristics taken together suggest that the causes of low nutritional outcome measures of preschool children in India have more to do with systemic factors affecting virtually the entire population, whether these are inherited or sanctified by tradition, than with access to food by children in different socioeconomic classes. Hebitch et al. [26] found that within the same socioeconomic group, the effect of

TABLE 4. Mean weight and length/height of 0- to 35-month-old children according to age group and place of residence and percentage changes between 1998/99 and 2005/06

Age (mo)	Weight (kg)						Length/height (cm)					
	Urban			Rural			Urban			Rural		
	1998/99	2005/06	% change	1998/99	2005/06	% change	1998/99	2005/06	% change	1998/99	2005/06	% change
0–2	4.21	4.40	4.51	4.25	4.25	0.00	54.94	56.17	2.24	55.00	55.51	0.93
3–5	5.93	5.95	0.34	5.67	5.73	1.06	61.58	62.36	1.27	60.77	61.56	1.29
6–8	6.97	7.04	1.00	6.76	6.81	0.74	66.19	66.83	0.97	65.32	66.15	1.28
9–11	7.77	7.84	0.90	7.38	7.43	0.68	69.87	70.26	0.56	68.41	69.27	1.26
12–23	8.98	9.10	1.34	8.49	8.61	1.41	75.36	75.91	0.73	73.76	74.78	1.38
24–35	10.83	10.95	1.11	10.24	10.37	1.27	83.39	84.98	1.91	81.35	83.24	2.32
All ages	8.74	8.83	1.03	8.23	8.25	0.24	74.25	75.06	1.09	72.44	73.23	1.09

ethnic group is small (3% for length/height and 6% for weight), whereas the effect of socioeconomic group is 12% for length/height and 30% for weight.

Incidence of chronic child malnutrition

The high dispersion and slow growth in mean weight and length/height of preschool children in India that have been noted in the previous section are reflected in the incidence of chronic undernutrition among children when measured against the WHO standards. The cutoff points used are –2SD from the corresponding WHO standards. Using these cutoff points of weight-for-age and height-for-age values, we see whether a child is underweight or stunted and the corresponding degrees of prevalence are measured by aggregating these incidences. The prevalence and percentage changes of underweight and stunting among preschool children in India according to age group are shown in **table 5**. The rates of undernutrition and stunting were quite high in both surveys but were reduced during the period from 1998 to 2006. The percentage of stunted children decreased from 1998/99 to 2005/06 uniformly in all age groups. The percentage change in the prevalence of underweight was higher in the lower than in the upper age groups. The prevalence of underweight increased with age.

Many of these results are by now quite well known and have been extensively discussed in the literature. There are, however, two features of the patterns described in **table 5** that are of great consequence and that appear to have received less than adequate attention in the ongoing discourse. The first, and possibly the most important, is that the bulk of chronic undernourishment occurs in the very short age bracket of 5 to 11 months. It can be seen from the table that these 6 months contribute 29.4 percentage points to the prevalence of underweight children and 16.9 percentage points to the prevalence of stunting in the year 1998/99. The corresponding figures in the year 2005/06 are 28.5 and 14.6 percentage points. These figures, when compared with the maximum malnutrition that occurred (54.1, 54.5, 49.4 and 46,7 respectively) in the age group 0 to 35 months become 54.3%, 31.0%, 57.7% and 31.3% respectively. In other words, more than 50% of the damage in the case of malnutrition and more than 30% of the damage in the case of stunting occurs within this short period. It is perhaps not coincidental that this also corresponds with the weaning period and the transition to a semisolid diet. The evidence, therefore, strongly suggests that the prevalence of chronic undernutrition among Indian children can be traced mainly to breastfeeding and weaning practices in the country. The stability of the distributions discussed earlier further suggests that the problem cuts across regions and socioeconomic categories.

The second feature of note is that both measures of chronic undernourishment peak in the second year of life. We have already seen that the contribution of stunting compared with that of underweight is less during the period from 6 to 11 months. This is because the increase in the percentage of stunting persists at the same rate even after the age of 11 months. However, the percentage of stunting increases at a declining rate as the child approaches the age of 23 months and declines after 23 months. Thus, in the third year, the prevalence either stabilizes (underweight) or actually declines (stunting). In other words, the rates of increase in both weight and length/height of Indian children from the 23rd month onwards are at least on a par with international norms, having lagged severely in earlier months.

Table 5 shows that the amount of improvement from 1998/99 to 2005/06 was greater for stunting (–21.6%) than for underweight (–8.8%). In the case of stunting, the percentage changes for children in both areas of residence were almost the same: –20.0% in rural and –18.1% in urban areas (not shown in **table 5**). In the case of underweight, the improvement in urban areas was almost twice that in rural areas: –9.8% vs. –5.0%. Tarozzi and Mahajan [27] made a similar finding; by comparing NFHS-1 and NFHS-2 data, they found that the number of underweight children decreased

TABLE 5. Percentage of underweight and stunting of 0- to 35-month-old children and changes between 1998/99 and 2005/06

	1998/99		2005/06			1998/99		2005/06		
Age (mo)	*n*	% underweight	*n*	% underweight	% change	*n*	% stunted	*n*	% stunted	% change
0–2	1,669	6.7	1,191	5.8	–13.43	1,669	9.8	1,191	6.8	–30.61
3–5	2,476	13.9	2,049	10.4	–25.18	2,476	17.3	2,049	11.4	–34.10
6–8	2,312	26.6	2,203	23.8	–10.53	2,312	25.2	2,203	19.0	–25.79
9–11	1,910	43.3	1,970	38.9	–10.16	1,910	34.2	1,970	26.0	–23.97
12–23	8,305	53.6	7,705	49.4	–7.83	8,305	54.5	7,705	46.7	–14.31
24–35	8,216	54.1	6,134	49.4	–7.76	8,216	53.3	6,134	38.0	–28.70
All ages	24,888	43.4	21,252	39.6	–8.75	24,888	43.1	21,252	33.8	–21.57

by 3 percentage points in rural areas and 5 percentage points in urban areas.

When the results are analyzed according to zone, it is seen that there was overall improvement in both indicators in all zones except the Northeast Zone, where there was a mild increase (2.7%) in the percentage of underweight children. In this zone, the percentage of underweight children declined in urban areas (–8.0%) but increased significantly in rural areas (10.1%). The changes by zone, however, mask considerable variation at the state level.

In the Northeast Zone, for example, the states like Manipur, Mizoram and Tripura have recorded progress even in the percentage of underweight children, whereas in Arunachal Pradesh there were increases in the percentages of both underweight and stunted children of 61.5% and 38.9%, respectively. On the other hand, in the Northern Zone, Rajasthan, the poorest state, showed decreases in the percentages of underweight and stunted children of 38.7% and 15.1%, respectively, whereas the better-off states showed a mixed bag of results. In the East and Central zones, the poor states of Orissa and Uttar Pradesh showed remarkable progress, whereas the other two poor states of Bihar and Madhya Pradesh continued to have poor rates of improvement in the percentage of underweight children. Remarkably, Kerala, long held up as the poster boy of health indicators in India, showed an increase in the prevalence of underweight children, whereas Andhra Pradesh and Tamil Nadu continued to make progress. In the West, surprisingly, Goa performed poorly in indicators, and even Maharashtra and Gujarat showed mixed results. In short, there is no obviously discernible pattern in performance on nutritional outcome indicators according to state.

We turn now to the changes in the prevalence of undernutrition according to socioeconomic characteristics (**table 6**). These characteristics were obtained from the literature where they have been cited as possible intervening factors in determining child health status. There are a priori expectations regarding the manner in which these factors would impinge on child development indicators. As can be seen from **table 6**, there are significant variations seen in the case of underweight children, many of which do not correspond with the a priori expectations. First and foremost, girls showed better improvement than boys. Tarozzi and Mahajan [27] obtained the opposite result using earlier data from NFHS-1 and -2. Christian children did not show any improvement, and children of "other" religions (i.e, Parsees, Jains, Sikhs, etc.) showed deterioration. Children of women educated to the secondary level showed very little improvement compared with children of more educated mothers, and children of professionals, technical, and clerical mothers showed deterioration. In short, the data from the two surveys do not unequivocally support many of the a priori expectations regarding the relationship between nutritional indicators and postulated characteristics. On the other hand, there was an almost uniform decrease in the percentage of stunted children in all the categories, with only two exceptions. First, Christians and "others" showed less improvement than Hindus and Muslims, which is contrary to expectations. This is possibly because the Christians and "others" had already improved their health status to a reasonable level. Second, children of households where only the husband makes the decisions regarding the expenditure of the wife's earnings also showed less improvement, an expected result. In the latter case, however, it should be noted that there was a sharp decline in the proportion of such households in 2005/06 as compared with 1998/99, which could indicate a self-selection bias.

On the other hand, there are significant variations in the case of underweight children, many of which do not correspond with the a priori expectations. First and foremost, girls show better improvement than boys. This is in contrast to the findings of Tarozzi and Mahajan [27], who obtained the opposite result using NFHS-1 and -2 data. Christian children did not show any improvement, and the "other" children showed deterioration. Children of women educated to the secondary level and children of professional, technical, and clerical women showed deterioration. In short, the data from the two surveys do not unequivocally support many of the a priori expectations regarding the relationship between nutritional indicators and postulated socioeconomic characteristics.

It is evident, therefore, that neither regional patterns nor socioeconomic characteristics provide any systematic explanation of either the prevalence of, or the changes in, the indicators of undernourishment among preschool children in India. Although this runs counter to the prevailing discourse in India, it lends support to our observation made in the previous section that there are more fundamental factors at work that drive the growth of Indian children.

Sources of change

It may, however, be argued that the changes in the nutritional indicators may be determined by changes in regional distributions and the socioeconomic characteristics rather than their levels at a point in time. To examine this hypothesis, we performed linear regression analysis to determine the influence of different socioeconomic variables on the temporal change of undernutrition (the results are not presented in tabular form). State-wise percentage differences of undernutrition, such as weight-for-age and height-for-age, between two time periods were considered separately as dependent variables. Differences of relevant factors of the socioeconomic variables in terms of percentage of population of, e.g., female, urban, Christian and

TABLE 6. Percentage of underweight and stunting among 0- to 35-month-old children in relation to socioeconomic variables and changes between 1998/99 and 2005/06

Variable	1998/99			2005/06			% change in underweight	% change in stunting
	n	% underweight	% stunted	*n*	% underweight	% stunted		
Sex								
Male	13,034	42.2	42.5	11,236	39.4	33.7	−6.63	−20.70
Female	11,854	44.6	43.8	10,016	39.8	33.9	−10.76	−22.60
Residence								
Rural	18,149	46.2	46.4	13,458	43.9	37.1	−4.98	−20.04
Urban	6,739	35.7	34.3	7,794	32.2	28.1	−9.80	−18.07
Religion								
Muslim	3,423	44.3	44.7	3,403	40.4	34.9	−8.80	−21.92
Hindu	18,562	45.6	44.4	14,858	41.3	34.3	−9.43	−22.75
Christian	1,715	28.0	32.4	1,991	28.0	29.7	0.00	−8.33
Other	1,188	27.8	33.7	977	33.8	30.2	21.58	−10.38
Mother's education								
Illiterate	11,900	52.8	53.0	8,118	51.1	43.8	−3.22	−17.36
Primary school	4,184	45.1	43.7	2,988	42.3	37.2	−6.21	−14.87
Secondary school	6,483	33.3	32.8	8,324	32.3	27.1	−3.00	−17.38
Higher	2,314	20.1	20.0	1,821	16.9	14.1	−15.92	−29.50
Mother's occupation								
Not working	17,280	40.3	40.8	14,190	35.9	30.7	−10.92	−24.75
Agriculture	5,133	53.6	51.7	4,442	50.9	42.9	−5.03	−17.02
Manual	1,628	51.4	47.9	1,256	49.1	42.1	−4.47	−12.11
Professional, technical, or clerical	847	29.0	30.2	1,364	30.7	27.1	5.86	−10.26
Mother's body mass index								
Under-nourished	8,915	54.8	48.5	7,141	52.2	41.5	−4.74	−14.43
Normal and above	15,973	37.0	40.1	14,111	33.2	29.9	−10.27	−25.43
Standard of living index								
Low	7,701	54.3	52.4	4,742	54.4	46.1	0.18	−12.02
Medium	12,045	43.6	43.4	6,681	43.9	38.1	0.69	−12.21
High	4,850	25.4	27.3	7,769	28.0	23.9	10.24	−12.45
Who decides how mother's income is spent								
Mother	1,376	45.6	43.5	867	43.4	36.6	4.82	−15.86
Husband / Father	1,341	56.5	53.6	502	53.6	49.0	−5.13	−8.58
Husband / Father and mother	1,339	47.1	45.9	2,378	44.5	38.2	−5.52	−16.77
Others	361	52.6	45.7	165	46.1	38.2	−12.35	−16.41
All India	24,888	43.4	43.1	21,252	39.6	33.8	−8.7	−21.6

other religious groups variables, literate mother, high professional working mother, mother with normal health status, and high standard of living household, have been taken as determining variables. In this analysis, women's decision-making power regarding spending of their own earnings has not been considered due to small sample size in respect of other variables. It is important to note that differences of two time periods have been considered in respect of 26 states only which are common to both the periods. Levels of significance of $p = .01$, .05, and 0.1 have been considered.

The regression analysis depicts the impact of changes in some important sociodemographic variables on the changes in underweight and stunted children

separately for rural, urban, and all India cases. In all regression analyses, mother's education is the only variable that has a significant effect on undernutrition and stunting. These results again reinforce the broad conclusion of this study that the prevalence of undernutrition among preschool children and its changes are probably driven more by inherited factors and common practices than by current nutrition and environment.

Discussion

This study examined the growth and nutritional status as well as their trends among preschool children in India using comparable data from two national-level surveys conducted in 1998/99 and 2005/06. We found that, contrary to expectations, the distribution of weight and length/height around the mean remained remarkably stable over age. An even more startling finding is that these distributions remained virtually identical in two independent surveys separated by 7 years. Such distributional stability cannot be coincidental and demands a cogent explanation. It is not within our competence to provide such an explanation, but no diagnostic or prescriptive analysis of childhood undernutrition in India can be credible unless it is consistent with this phenomenon.

We also found that the dispersions of both weight and length/height around the mean were much greater in India than the international norms.* Furthermore, the rates of growth of mean weight and length/height were much lower in India than the international norms up to the age of 2 years but caught up with, or even exceeded, the international norms after that age. This may indicate that breastfeeding and weaning practices are much more important factors than solid food intake. Moreover, the stability of the distributions implies that such practices, or at least their impacts, are much more ubiquitous than can be explained by social and economic differences within the population.

Measures of dispersion, however, can shed considerably more light than their use to determine the significance of the changes in the means. The various conjectures that exist in the literature regarding the causes of child undernutrition in India, some of which have been cited in the Introduction above, emphasize the quality of nutrition and the role of poverty and intrahousehold distribution of food. If these conjectures are correct, then we should expect to observe an increasing dispersion of length/height and weight measures with increasing age as nutritional and/or environmental factors progressively dominate the inherited factors, whether genetic or maternal.

The period from birth to 6 months contributes more than 29 percentage points to the prevalence of underweight children and more than 16 percentage points to the prevalence of stunting. It is perhaps not coincidental that this period corresponds to the period of weaning and transition to a semisolid diet. The evidence, therefore, strongly suggests that the prevalence of chronic undernutrition among Indian children can be traced mainly to breastfeeding and weaning practices.

The high dispersions and low growth rates of the means during the first 2 years for both weight and length/height translate to high rates of undernutrition and stunting. The rates of progress between two national-level surveys are not particularly impressive. The percentage decline in undernutrition (weight-for-age) among preschool children was 8.76% at the country level and 5.0% and 9.8% at the rural and urban levels, respectively, over the 7-year period. The magnitude of the change was higher for stunting (height-for-age): the percentage differences between the two studies were 21.6% at the country level and 20.0% and 18.1% at the rural and urban levels, respectively. The abrupt decline in stunting during this period may be due to continuous improvement in maternal health and education and in the availability of safe water, which occurred 20 to 30 years previously when today's mothers were children. Our results are consistent with those of Deaton and Dreze [15].

Analysis of possible regional and socioeconomic factors thought to influence child nutrition outcomes did not reveal any substantive causal relations or even strong patterns either in the cross-section or in the change. The rate of malnutrition was lower among children of educated mothers. With respect to the mother's occupation, the reduction was greatest among nonworking mothers and lowest among mothers with professional, technical, and clerical jobs. This is because higher income mothers with professional, technical, and clerical jobs had already attained low prevalence of child malnutrition. Moreover, mothers who work outside the home may have less time for child feeding and healthcare, with possible adverse nutritional outcomes [28]. This implication has been reflected among the children of agricultural and low-paid manual workers in our study. Thus, the analysis undertaken in this study suggests that the cause of the high-measured prevalence of childhood undernutrition in India may lie less in the way we treat our children and more in the way we treat our women. It is food for thought.

* An interesting implication of this observation is that India probably also has a higher proportion of overweight babies than the international norm, which could possibly be an explanatory factor for some of the prevalence of childhood obesity that has recently been noted in the literature. However, this issue was not examined in this study.

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