SENSITIVE INDEX TO ASSESS RISK OF MORBIDITY IN UNDER-NUTRITION

Final Report of the IDRC Supported Project

Nutrition Foundation of India, New Delhi
September 2009

Content Page

Executive summary

It is well documented that in preschool children undernutrition is associated with immune depression and increased risk of infections; infections aggravate undernutrition. Underweight, is the most widely used indicator for assessment of undernutrition and most of the studies investigating undernutrition and infection interactions have used this parameter. In India nearly half the children are stunted and under-weight; but majority of children have appropriate weight for their height and less than a fifth are wasted. The present study was undertaken to explore which of the five anthropometric indices for assessment of under-nutrition (weight for age, height for age, wasting, BMI for age, and wasting and stunting with low BMI) is associated with more consistent and higher risk of morbidity due to infection.

The National Family Health Survey-3 data base provides information on 56,438 preschool children on age, sex, weight, height, infant and young child feeding practices and morbidity due to infections in the last fortnight. Relative risk (RR) of morbidity due to infections was computed in infants and children with stunting, underweight, low BMI for age, wasting and stunting with low BMI (< mean-2SD of WHO 2006 standards).

Comparison of the RR for infections in undernourished children (as indicated by the above five anthropometric indices of nutritional status) showed that the relative risk of morbidity due to infections was higher and more consistently seen in children with low BMI and wasting as compared to stunting or underweight. The small group of children who had stunting with wasting had the highest relative risk of morbidity due to infection.

Low BMI-for-age and wasting indicate current energy deficit; early detection and correction of the current energy deficit might reduce the risk of infection and also enable the child to continue in its growth trajectory for weight and height. As low BMI for age is seen in only about 15 of children it will be possible to focus on this small group, provide the needed health and nutrition care, ensure that low BMI is quickly reversed and the child continues linear growth trajectory.

Study also provided an opportunity to compare the growth of Indian children with the WHO 2006 standards. Height, weight and BMI for age in Indian preschool children were computed using LMS software from the National Family Health Survey -3 data base and compared with the WHO (2006) standards. Prevalence of undernutrition as assessed by for height, weight and BMI for age were also computed.

During the first few months Indian children are exclusively breast fed and are relatively free from infections; as a result underweight and stunting rates are similar to the low birth weight and stunting at birth. There was a progressive increase in underweight and stunting between 3-23 months of age due to poor infant and young child feeding habits and increasing morbidity due to infections. Low BMI for age and wasting rates are highest in the first six months. There was is a slow but steady decline in the wasting and low BMI rates between 6-23 months, because increase in stunting rates were higher than the increase in underweight rates during this period.

These data indicate that low BMI is a sensitive indictor of current energy deficit. Early detection of energy deficit using BMI for age and expeditious correction of it is the most effective intervention for preventing stunting. It is important to prevent of stunting especially in the first two years, because once stunting has occurred, it may not readily reversible.

Dissemination of the findings

Results of the study were presented in the international "Symposium on Maternal and child nutrition - a life cycle approach" organized by the Nutrition Foundation of India in November 2008

Two manuscripts have been prepared based on this study

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Policy and programme implications of the research study

The WHO (2006 and 2007) has provided the standards for BMI in children and adolescents for use by member countries for detection of both under and over nutrition. While BMI for age has been widely used for detection of over weight /obesity in India and other developing countries, BMI for age has not been used widely for assessment of under-nutrition in children even in hospital setting where height measurements and computation of BMI are not difficult. This might at least in part be because of lack publications indicating that BMI of age is a useful indicator for assessment of risk functional decompensation (increased susceptibility to infection) associated with undernutrition. Data from the present analysis indicate that that low BMI-for-age and wasting which take into account the weight for height have a more consistent association with infection in Indian preschool children as compared to weight for age.

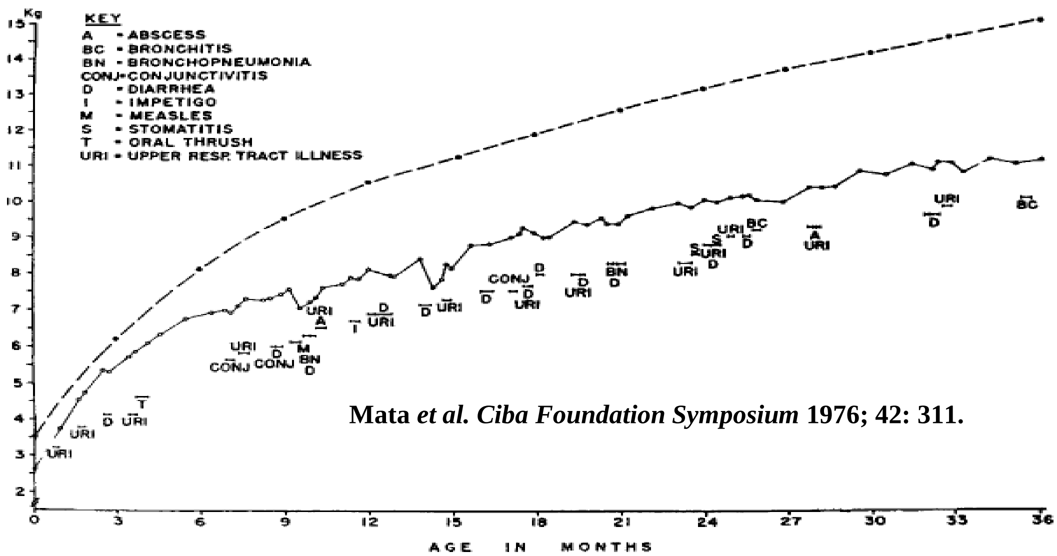
It is hoped that this finding from secondary data analysis will pave way to research studies with primary data collection exploring the usefulness of BMI for age for assessment of risk of infections as compared to weight for age. If the findings of the present study are confirmed by other studies it might lead to as the wider use of this BMI for age for assessment of undernutrition in clinical settings and surveys in India. This in turn might lead to increasing use of a single indicator (BMI for age) for assessment of both under and overnutrition. In view of the known high stunting rates in Indian children, use of BMI-for-age for monitoring nutritional status children might help in early detection of children having low or high BMI and effective management of both under and overnutrition; such interventions could result in reduction in the immediate risk of morbidity due to infections and long term risk of non-communicable diseases.

The demonstration of association between current energy deficit and morbidity may have policy and programme implications also. In India only about one fifth of the children have low BMI-for-age; it might therefore be possible to focus the attention on detection of under-nutrition (low BMI) and correction through increase in dietary intake under programme conditions. Early detection and correction of low BMI might reduce the risk of infection and also enable the child to continue in its growth trajectory for weight and height. Nearly one third of preschool children suffer from morbidity due to infections; early detection and treatment of infections through primary health care may go a long way in preventing deterioration in nutritional status of children. Wider use of BMI for age for early detection and correction of current energy deficit /excess can prevent both further stunting and overnutrition. This is especially important in India because recent studies have shown that undernutrition in early childhood followed by rapid improvement body mass index in early/ late childhood/ adolescence may predispose to overnutrition and non-communicable disease risk in early adult life .

Chapter 1
Background information

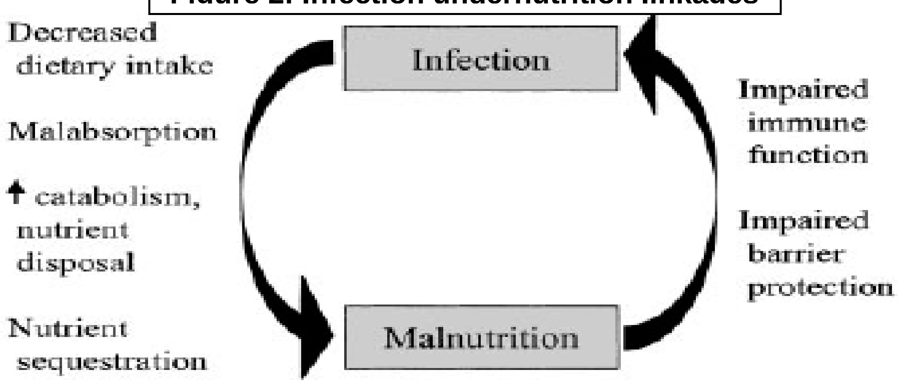
It is well recognized that preschool children are a nutritionally vulnerable segment of population; they are also very susceptible to morbidity due to infections. The interrelationships between nutrition and infections have been well documented. Infections aggravate under-nutrition; under-nutrition is associated with impaired immune function which results in increased susceptibility to infections; (Figure1 and 2); if this vicious cycle continues it can result in death of the child.

Figure 1 Effect of infections on body weight



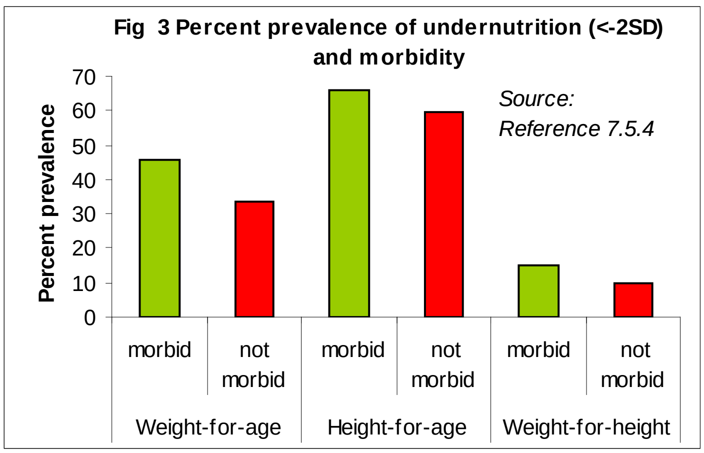
Mata *et al. Ciba Foundation Symposium* 1976; 42: 311.

Figure 2: Infection undernutrition linkages

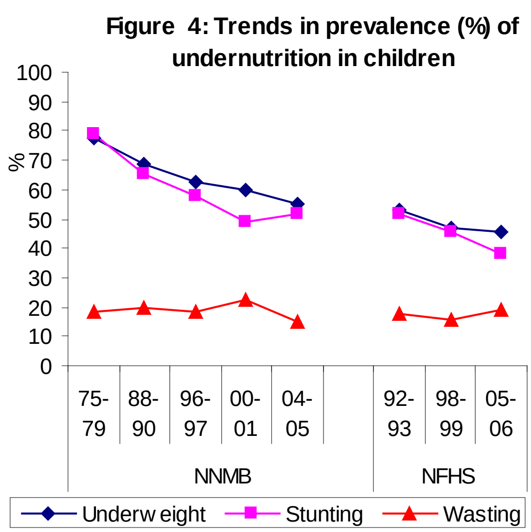


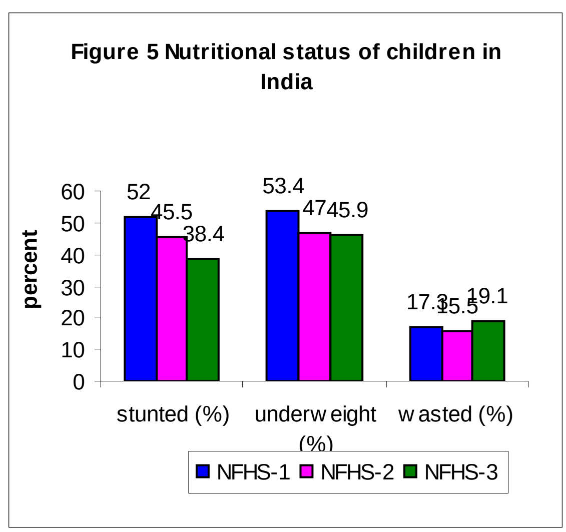
Nutrition component of primary health care services (National Rural Health Mission (NRHM) and its urban counter part in India provides access to simple , time tested remedies for common infections (diarrhea, fever and respiratory infections), to reduce duration and severity of the morbidity as well as the adverse impact of infections on nutritional status. Nutrition component of primary health care services (National Rural Health Mission (NRHM) and its urban counter part in India) in collaboration with Integrated Child Development Services aim at universal screening of all children for early detection and appropriate interventions to correct the undernutrition (Tenth Five Year Plan , GOI).

Studies carried out all over the world have shown that prevalence of undernutrition is higher in children who had morbidity in the last fortnight, though it is difficult to state whether undernutrition preceded the morbidity or morbidity preceded or aggravated undernutrition. Data from a recent NFI study on under-nutrition rates (as assessed by weight for age, height for age and wasting) in children who had experienced a morbidity episode in the last fortnight as compared to those who did not is shown in Figure 3, indicating that the association between undernutrition and infection exists even in urban areas in the current decade..



Nutrition scenario in India





Data from surveys carried out by National Nutrition Monitoring Bureau and National Family Health Surveys on time trends in under-nutrition rates as assessed by under weight, stunting and wasting is given in Figures 4 and 5. There has been sustained if slow reduction in stunting and under weight rates, but no change in the wasting rates. The decline in undernutrition rates has been mainly been attributed to the increased access to health care and consequent reduction in nutrient loss due to infections ; to some extent the nutrition supplementation programmes might also have contributed to the reduction in undernutrition in preschool children. Under-nutrition rates as assessed by weight (underweight) and height (stunting) in Indian preschool are higher than the undernutrition rates in Sub-Saharan Africa but morbidity and mortality rates are lower in Indian children; this paradox has attracted global attention as "South Asian enigma".

Nutrition scientists in India are worried that over the last three decades, there has been no reduction in wasting rates, indicating that current energy deficit in preschool children remains unchanged. Unless it is detected early and corrected effectively, wasting would result in further fall in growth trajectory for height and weight and aggravation of stunting and undernutrition. There has been a growing concern among programme managers and policy makers that over years the outlays in nutrition programmes have not resulted in commensurate improvement in the out come in terms of reduction in under nutrition.

India is currently undergoing rapid economic, demographic, health and nutrition transition. While under-nutrition in children continues to be a major public health problem among poorer segment of the population, over-nutrition in children is emerging as a major problem among the urban affluent segments. Indian children from low income groups are shorter than their developed country counter parts and better income group compatriots. As they are short they will continue to weigh less and be classified as undernourished by weight for age and height for age standards, even though they are appropriate weight or over weight for their height. Unless appropriate interventions (in terms of improving physical activity) are taken up they will incur all the risks associated with overnutrition.

Use of BMI for age for assessment of nutritional status in children

Weight for age over estimates under-nutrition in stunted children, because many of the low weight for age children may have appropriate weight for their current height. Paediatricians in India recognise this problem and clinically categorize children on the basis of height and weight into

- those who are normal height and weight (no intervention needed);
- those who are tall and slim or normal height and slim or short and slim (need more food)
- children who are normal weight for their height even though they are short (stunted but appropriate BMI for their height, requiring no intervention)

➢ children who are short and overweight for their height or normal height and overweight or tall and overweight (requiring exercise) (Figure 6)

Among the stunted children three categories can be identified on the basis of weight for height:: those who have appropriate weight for their height, those who are wasted for their current height and those who are overweight for their height (Figure 7). Immediate and short term interventions in these three categories of children differ: those with wasting require correction of energy deficit ; those who are over weight for their height should be advised to increase more physical activity; those who are short but have appropriate BMI for age need no intervention.

Figure 6: Nutritional status of children- BMI classification

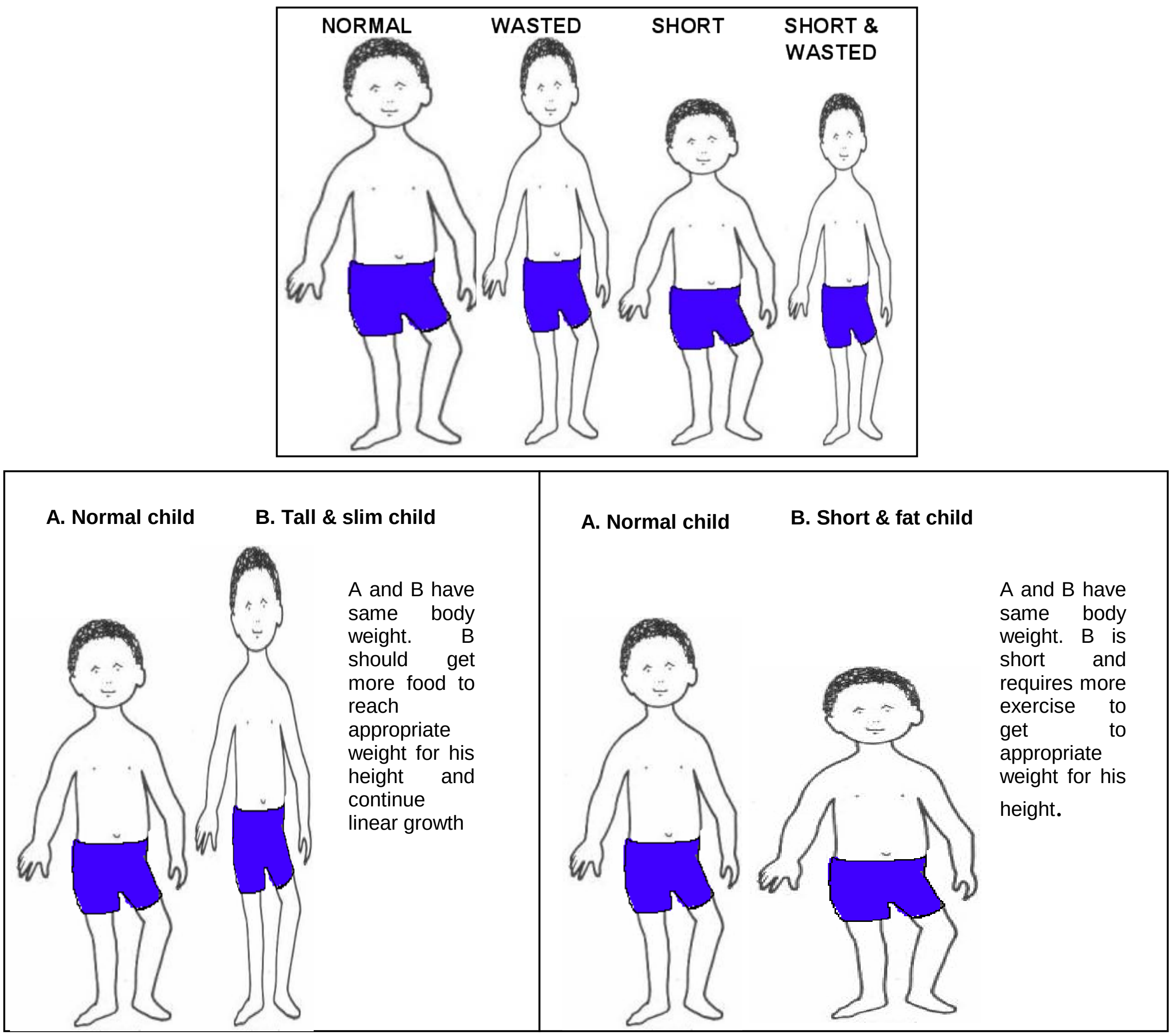
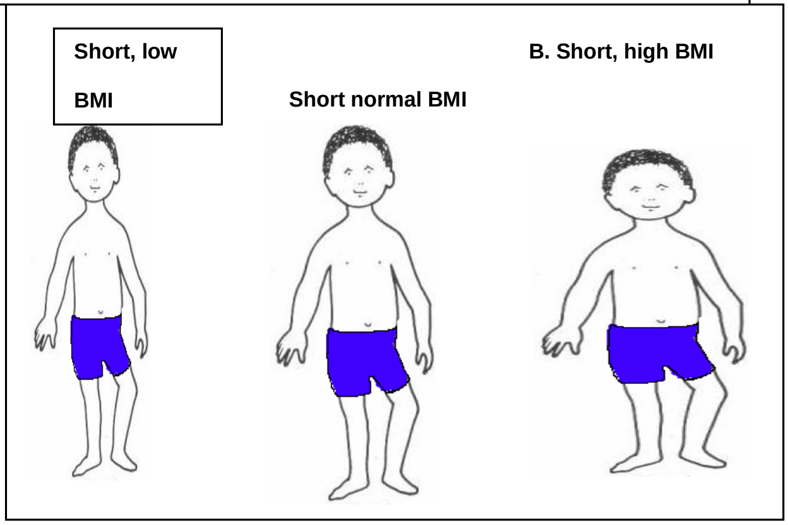


Fig 7: Nutritional status of short children on the basis of BMI



Some of the data from India indicate that in families which are no longer having any economic constraints in accessing food, under-nutrition in early childhood may lead to overnutrition and increased risk of non-communicable diseases in adult life. High prevalence of stunting and emergence of dual nutrition burden makes it imperative that India uses an index which will help in early detection of both under and over nutrition so that they could be managed effectively.

Chapter 2
Hypothesis, Study Design and Sample Size

Hypothesis

Use of BMI for age for assessment of overnutrition has gained wide acceptance among the clinicians and epidemiologists because there were data on potential health risk associated with over-nutrition i.e. biochemical finding suggestive of increased risk of diabetes and cardiovascular disease risk. Developed countries where over-nutrition was a major problem accepted and started using the International Obesity Task Force's recommendation regarding use of BMI for age for detection of overnutrition in children. CDC evolved standards for BMI for age to define over-nourished American children.

WHO in 2007 has published the standards for weight, height and BMI for age for boys and girls in the age group 0-18 years. For the first time WHO has provided the standards for BMI for age, which can be used for detection of both over and under nutrition in children. This is very timely considering the emergence of dual nutrition burden in many developing countries where stunting is common and overweight short children get misclassified as undernourished (underweight for age and stunted***).*** The rationale for use of BMI for age for detection of under-nutrition is that low BMI for age is an accurate measure of current energy deficit; early detection correction of this deficit will enable the child to continue in its growth trajectory for weight and height. The fact that only about one sixth of the children have low BMI for age makes its detection and correction feasible under programme conditions. But BMI for age has not yet been widely used for assessment of undernutrition in children either in clinical practice or in nutrition surveys. Use of BMI for age for detection of under-nutrition will gain better acceptance if evidence on the magnitude of increased risk of infection in children with low BMI is available.

Objective

General

To conduct a secondary analysis of the National Family Health Survey-3

- to gain a better understanding of morbidity associated with undernutrition as assessed by different indices currently in vogue for assessment of nutritional status in preschool children
- to test whether in Indian children among whom stunting is common, body mass index (BMI) for age is a more sensitive index than stunting and underweight for assessment of risk of infection

Specific:

Using a sample of 46,000 preschool children from the National Family Health Survey, the secondary analysis will:

- assess the relative risk of morbidity due to infections with undernutrition (stunting, underweight and low BMI for age)
- assess whether BMI for age is the most sensitive index for assessment of risk of morbidity due to infections in population groups where stunting in childhood is very common.

Sample size

In India prevalence of under-nutrition **(<mean -2SD of BMI for age WHO standards 2006**), is between 10 - 15 % in different states. Prevalence of morbidity due to infections ranges between 10- 12 %. Assuming that the risk of infection in low BMI is 50 % higher (eg. morbidity rate in normal BMI children is 10% and morbidity rate in low BMI children is 15 %), the sample size required will be approximately 40,000 children.

<u>Sample size calculations</u>

$$N = \frac{(p1xq1)+(p2xq2) \text{ x } 1.96+1.24}{(P1q1)^2}$$

p1 10% p2 15%
2Alpha 1.96
2 beta 1.24
q1 1-.1 =0.9
q2 1-.15 = 0.85

$$N = \frac{\{ (10x0.9)+(15x0.85)\} \text{ x } 1.96+ 1.24}{(10-15)^2}$$

N = 4577
Prevalence of low BMI = 10 % so sample required is about 46000

P1 normally nourished
P2 undernourished
One tailed 5% significance RR 1.5

The sample size computations have used BMI for age because the prevalence of stunting and under weight are quite high and would require a smaller sample size . The relative risk of morbidity between the normal and under nourished, as assessed by weight for age , height for age and BMI for age will then be compared to see which of these three indices is the best .

Study design

The National Family Health Survey -3 has data base provides the following information in about 46,000 preschool children : age, sex, weight, height and morbidity due to infections in the last fortnight. The data base is available free of charge to all research institutions and NFI already has a copy of the data sets .

The data sets in different files have to be linked and analyzed to look at relative risk of morbidity due to infections in relation to stunting, under weight and low BMI for age .

First the children will be classified on the basis of the new age and sex specific WHO growth standards into

- normal (between mean –2SD and +2 SD)
- undernourished (below mean -2SD) and
- overnourished (over mean +2 SD)

according to weight , height and BMI for age .

From the morbidity records children will be classified as not having any infections (no symptoms) and those having symptoms of infection (diarrhea, cough or fever).

Means and SD height, weight and BMI for age for children belonging to different age groups (6 monthly age groups) will be computed in the group that has infections and the group that does not have infections . It is expected that the group with infections will have a lower mean weight and BMI for age and the mean height (which represents the cumulative impact of chronic undernutrition) may or may not be significantly lower group with infections .

The relative risk of undernutrition (mean-2 SD) in morbid children versus those without morbidity will be computed for each of the three indicators (weight for age , height for age and BMI for age) .

Comparison of the relative risk of morbidity between the three indicators will be made to assess which of the three indicators are the most sensitive index for the association between undernutrition and morbidity.

Chapter 3
National Family Health Survey

The National Family Health Survey (NFHS) is a large-scale, multi-round survey conducted in a representative sample of households throughout India. Three rounds of the survey have been conducted since the first survey in 1992-93. The survey provides state and national information for India on fertility, infant and child mortality, the practice of family planning, maternal and child health, reproductive health, nutrition, anaemia, utilization and quality of health and family planning services.

The Ministry of Health and Family Welfare (MOHFW), Government of India, designated the International Institute for Population Sciences (IIPS), Mumbai, as the nodal agency, responsible for providing coordination and technical guidance for the survey. IIPS collaborated with a number of Field Organizations (FO) for carrying out the survey. Each FO was responsible for conducting survey activities in one or more states covered by the NFHS. Technical assistance for the NFHS was provided mainly by ORC Macro (USA) and other organizations on specific issues. The funding for different rounds of NFHS has been provided by USAID, DFID, the Bill and Melinda Gates Foundation, UNICEF, UNFPA, and MOHFW, GOI.

As the name suggests NFHS-3 is the third in the NFHS series of surveys. NFHS-3 fieldwork was carried out by 18 Research Organizations including some Population Research Centres. The NFHS-3 sample covers 99 percent of India's population living in all 29 states. Fieldwork for NFHS-3 was conducted in two phases from November 2005 to August 2006

Coverage under NFHS3

All the 29 states of India are covered. In these slum and non-slum areas of eight cities, i.e. Chennai, Delhi, Hyderabad, Indore, Kolkata, Meerut, Mumbai, Nagpur wherein Interviews were carried out in 109,041 households in which there were about 56,438 pre school children. The NFHS sample covered in the 29 states is as given in the Fig3.1.

Socio-demographic profile of NFHS population

Among these households 41% of the population belonged to the OBC category, 19% were scheduled castes, 8% were scheduled tribes and the rest belonged to the "Others" category (Fig3.2). The distribution of these households by wealth index and residence indicates that most of the household in the rural areas belonged to the middle income group with maximum households in the "rich"household category being in the urban areas (Fig3.3). The distribution of households by wealth index and caste showed that the backward classes were among the poorer sections of the society (Fig3.4). Of the selected households it was noted that in the urban areas almost all the households had electricity however only 50% of these had piped water facility. The numbers however, reduced in the rural areas where a little more than half the population surveyed had electricity and about 12 % had piped water facility (Fig3.5). The NFHS 3 reported that there was an improvement of 8% in household electricity and that 88% of the households had an improved source of drinking water and 29% had access to toilet facility (Fig3.6) as compared to the NFHS 2.

The NFHS 3 survey has also indicated that the percent distribution of men and women in the age group of 15-49 years by highest level of education is only 89% of men and 74% of women i.e. these are percentages of literate men and women respectively (Fig3.7). It was also observed that lesser percentage of women go through a bare minimum of 10 years of basic education with about 41% not availing of any school education at all. The percentage females dropping out of school is higher than that of males at every stage.

On the whole NFHS3 survey observed that there were substantial improvements in child survival; with improved immunization coverage with undernutrition and anaemia remaining major challenges.

Fig 3.1: Caste/Tribe Status

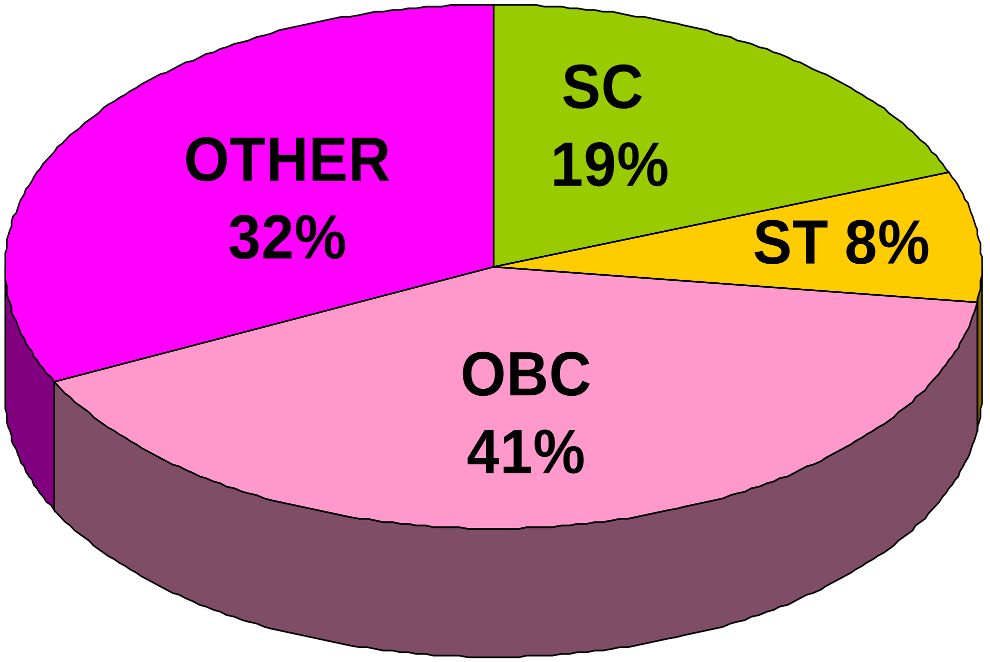


Fig 3.2:Distribution of Households by Wealth Index and Residence

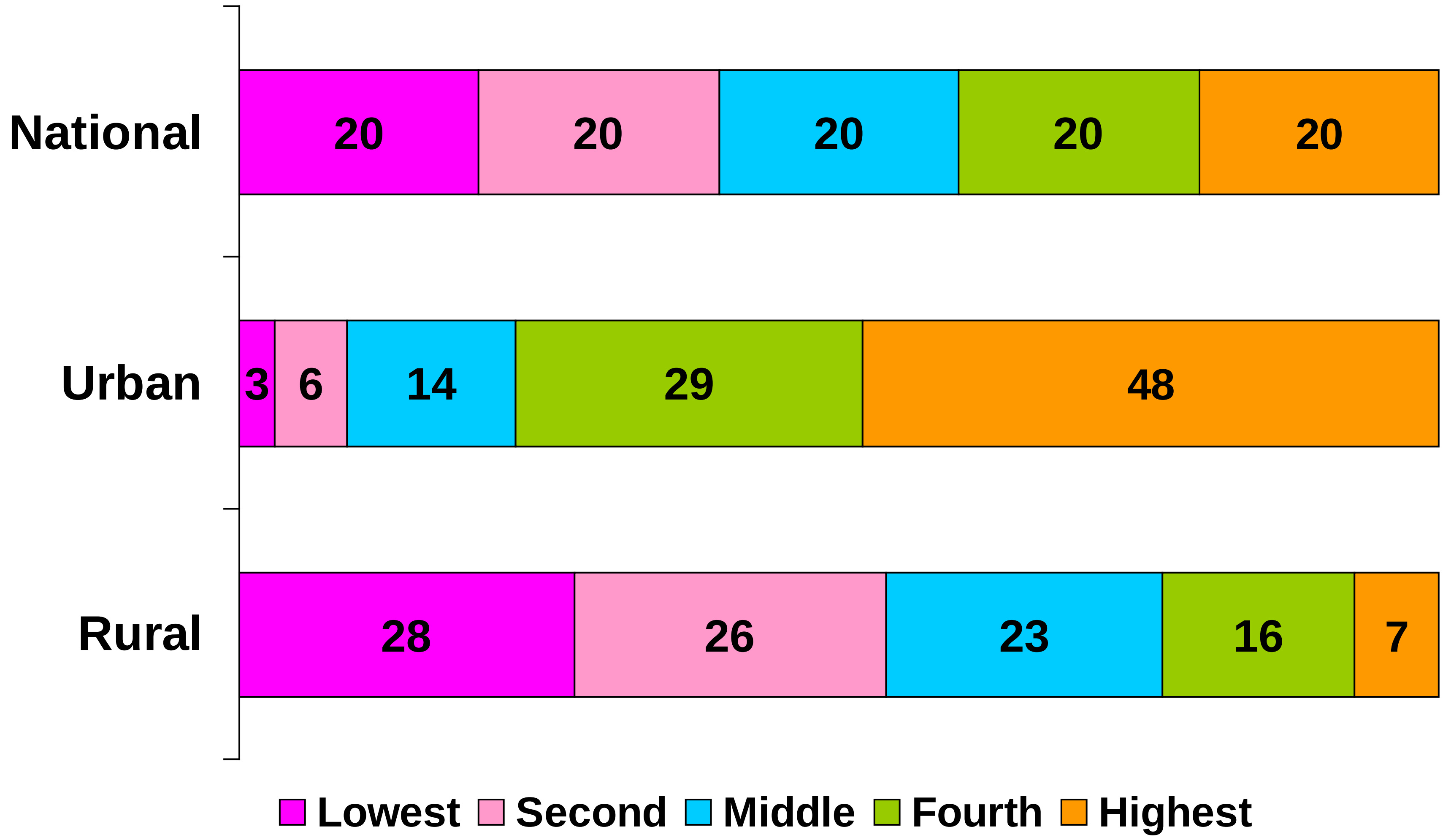


Fig 3.3: Distribution of Households by Wealth Index and Caste

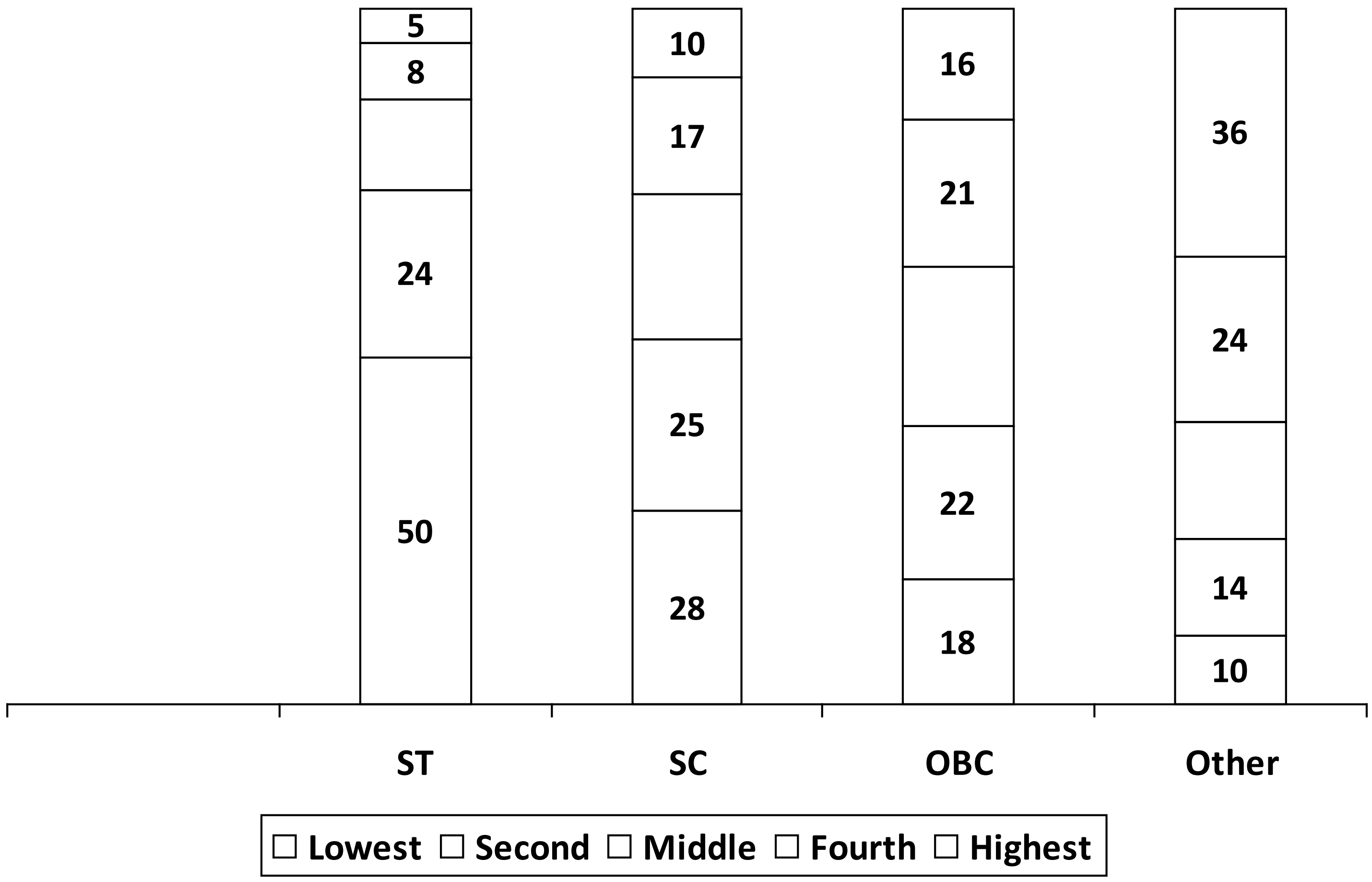


Fig3.4:Selected Household Characteristics

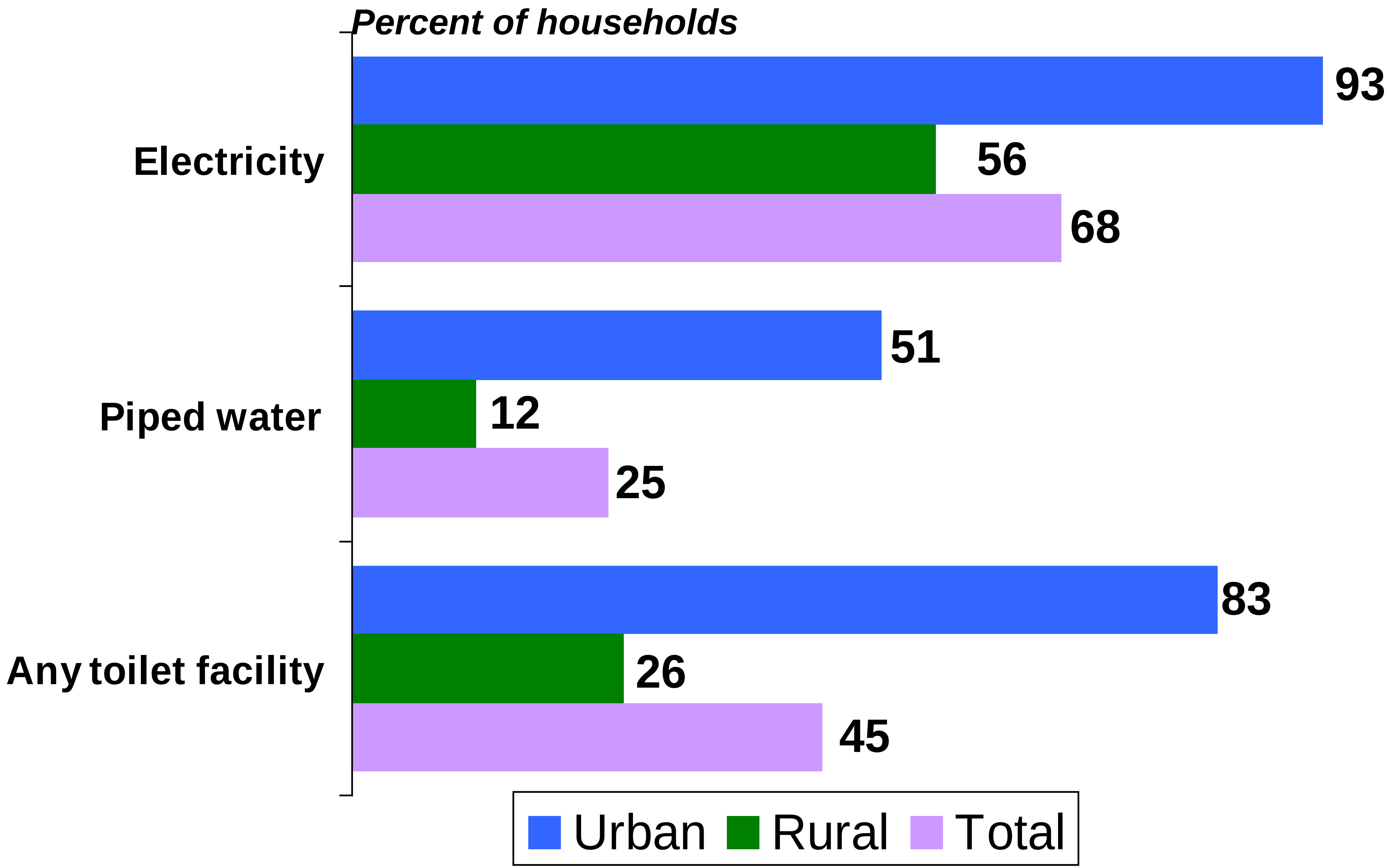


Fig 3.5:NFHS-3 finds some improvements in the household environment since NFHS-2

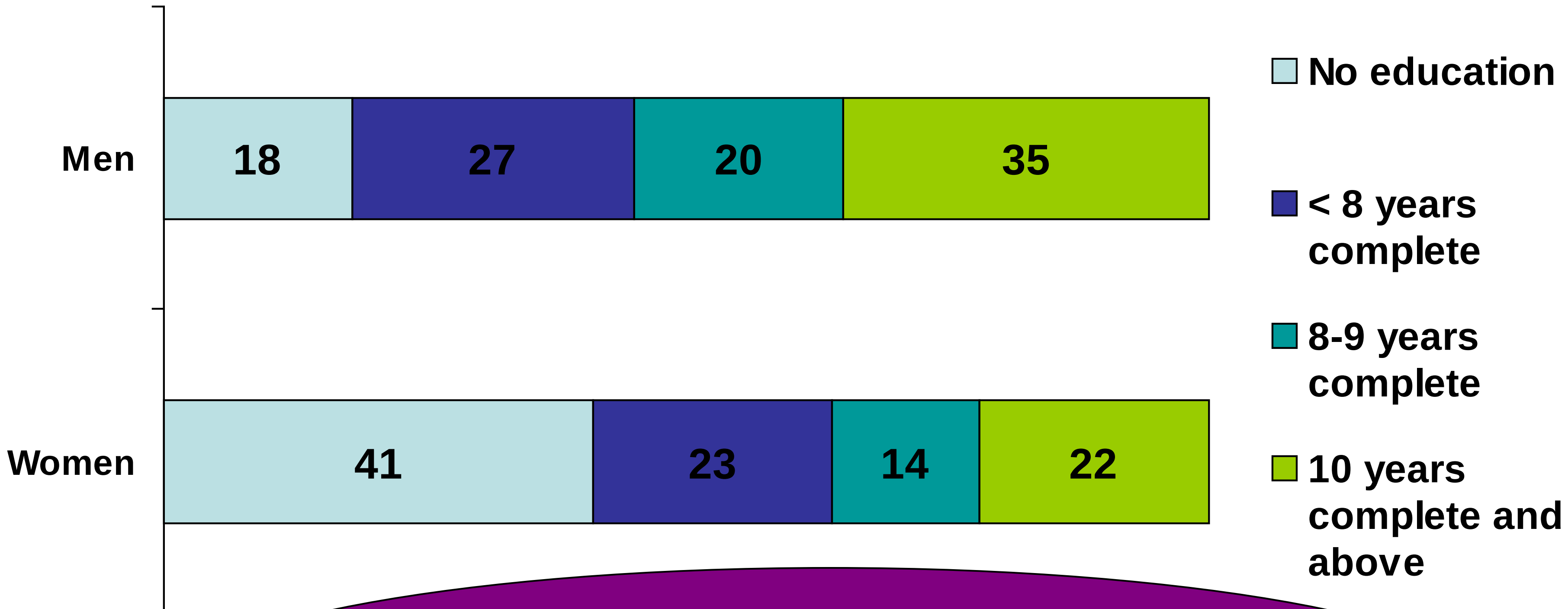
- 68% of households have electricity, up from 60% in NFHS-2

- 88% of households use an improved source of drinking water

- Only 29% of households have improved toilet facilities

Fig 3.6: Education

Percent distribution of men and women age 15-49 by highest level of education



NFHS-3 shows that even among those in the age group 15-19, only 89% of men and 74% of women are literate

Chapter 4
Summary of the findings from the study and its implications

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These data indicate that low BMI is a sensitive indictor of current energy deficit. Early detection of energy deficit using BMI for age and expeditious correction of it is the most effective intervention for preventing stunting. It is important to prevent of stunting especially in the first two years, because once stunting has occurred, it may not readily reversible.

The data analysis showed that BMI for age is the best indicator for assessment of functional decompensation in terms of increased risk of infections. Once the results of the analysis is available and published clinicians, epidemiologists will be able to mount hospital and community based studies to validate the findings from this pilot study.

Policy and programme implications

The fact that BMI for age has emerged as the best index for assessment of risk of morbidity due to infections, may have profound effect on the national policies and programmes for detection and management of undernutrition in preschool children.

International Obesity Task Force has already recommended use of BMI for age as the index for assessment of overnutrition in children because of the associated biochemical changes which are associated with increased risk of non-communicable diseases in adults . If it is demonstrated that the undernutrition as defined by BMI for age is a sensitive indicator for risk of infections it will go a long way brining about uniformity of indicators used for assessment of risks of morbidity in children .

If low BMI for age is an accurate measure of current energy deficit; early detection and correction of this deficit will enable the child to continue in its growth trajectory for weight and height.

Only about one sixth of the children have low BMI for age. They can be readily identified on the basis of weight and height measurements. Under programme conditions, providing supplementary nutrition and health care and monitoring improvement in health and nutritional status of one sixth of the children is a more feasible than trying to correct undernutrition (underweight and stunting) in half the children .

Dissemination of the findings

Results of the study were presented in the international symposium on “Maternal and child nutrition - a life cycle approach” organized by Nutrition Foundation of India in November 2008

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The full text of both these articles is given in **Annexure I.**
The results of the regression analysis for factors affecting nutritional status and morbidity are given in **Annexure -2.**

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Undernutrition and risk of infections in preschool children

Prema Ramachandran and Hema S Gopalan
Nutrition Foundation of India, New Delhi

It is well recognized that preschool children are a nutritionally vulnerable segment of population; they are also very susceptible to morbidity due to infections. Under-nutrition is associated with impaired immune function and consequent increased susceptibility to infections; infections aggravate under-nutrition; if this vicious cycle continues it can result in death of the child. Interactions between nutrient intake, nutritional status and morbidity in preschool children are complex. Major factors which modulate nutritional status during early childhood include birth weight, infant and young child feeding practices, morbidity due to infections, treatment of infections, nutrition care during infection and convalescence. Prevalence, severity and frequency of morbidity due to infections depend upon infant and young child feeding and caring practices, nutritional status of the child, and environmental hygiene. Effect of morbidity on nutritional status depends upon severity and duration of infection, health care provided and feeding during illness and convalescence. Because of multiplicity of factors influencing under-nutrition and morbidity, the relative risk of infection with any one factor is low.

Data from national surveys have shown that in India nearly half the preschool children are under-weight[1-5] or stunted[1-4] and but less than a fifth are wasted[1-4]. Weight for age is the most widely used index for assessment of nutritional status in children. Inspite of the very high under-nutrition rates (higher than sub-Saharan Africa), and high prevalence of morbidity due to infections (between 20-30% of preschool children are suffering from have morbidity due to infections[4]), under-five mortality rates in India are relatively low – so called "South Asian Enigma"[6]. In India where stunting rates are high, there has been growing concern about appropriateness of using weight for age for assessment of under-nutrition. WHO growth standards (2006) provide standards for BMI for age in preschool children and state that BMI could be used for assessment of both under and over nutrition in preschool children. There is global and Indian acceptance that BMI for age is an appropriate index for assessment of over-nutrition, because there are ample published data indicating that biochemical markers for increased risk of non-communicable diseases are seen in children with high BMI. However as yet there has not been a consensus that BMI for age is the appropriate indicator for assessment of under-nutrition especially in countries with high stunting rates; this is perhaps due to the lack of published data from the developing countries with high stunting rates that BMI for age is a better indicator than weight for age to assess the association between under-nutrition and infection. The present study was undertaken to explore which of the five anthropometric indices for assessment of under-nutrition (weight for age, height for age, wasting, BMI for age, and wasting and stunting with low BMI) is associated with more consistent and higher risk of morbidity due to infection.

Material and methods

The National Family Health Survey-3 data base provides the following information in about 56, 438 preschool children: age, sex, weight, height, infant and young child feeding practices and morbidity due to infections in the last fortnight. Data from NFHS 3 were obtained and analyzed for infant and young child feeding practices, prevalence of morbidity due to infections and nutritional status using WHO (2006) standards[7]. Relative risk and confidence intervals for risk of infections associated with undernutrition was computed with respect to height for age, weight for age, BMI for age, wasting and stunting with low BMI. There are massive differences in prevalence of both infections and undernutrition between different age groups in preschool children. Therefore relative risk of morbidity due to infections was computed in relation to under-nutrition (< mean-2SD of WHO 2006 standards) as assessed by the five anthropometric indices (weight for age, height for age , BMI for age , wasting and stunting and low BMI) in three different age groups 0-5 months, 6-11 months and 12-59 months.

Results

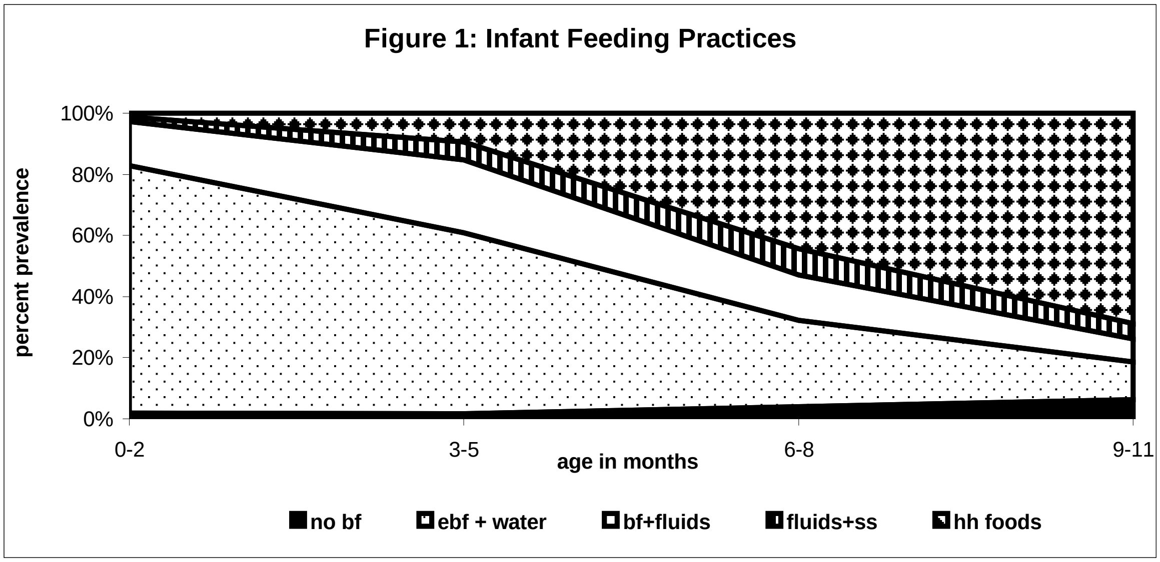
The number of children available for analysis from the NFHS-3 database is shown in Table -1. There were 45,377 infants and children with age, sex, height, weight (within the valid range) and morbidity data.

Table 1: **The study population**

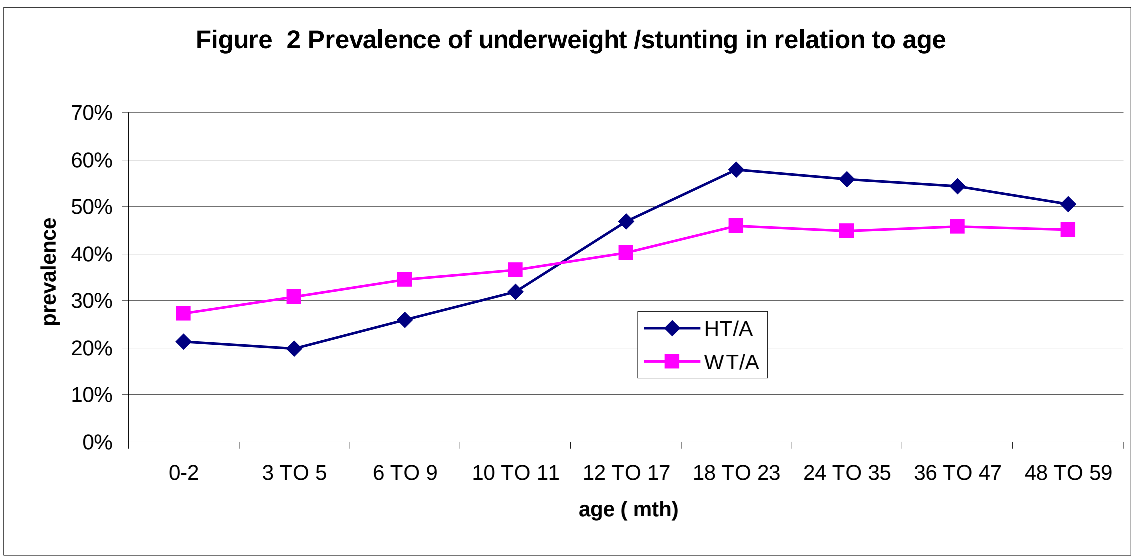
Total number of children surveyed	56438
No. of children with valid age (0-59 months):	52868
No. of children with valid weight (within range)	45377
No. of children with valid height (within range)	45377
Children with valid age, height, and weight:	
Male	23724
Female	21653

Infant feeding practices and infant nutrition

In India breast-feeding was nearly universal; however less than 50 % of infants were exclusively breast fed upto six months. Very few infants received complementary food at 6 months. Most of the infants over six months of age continued to be breast fed and were also given household food (Figure 1).

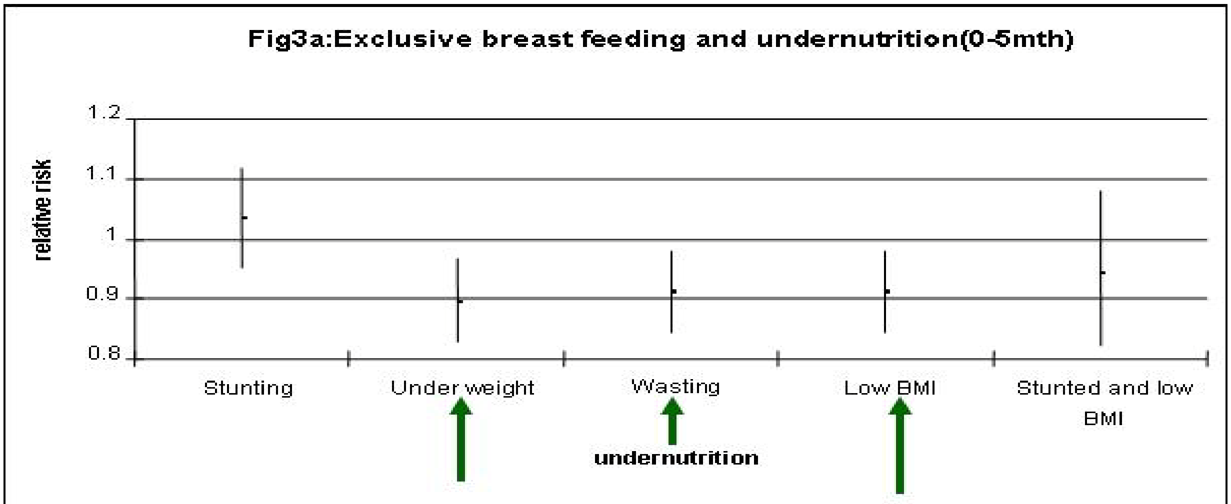


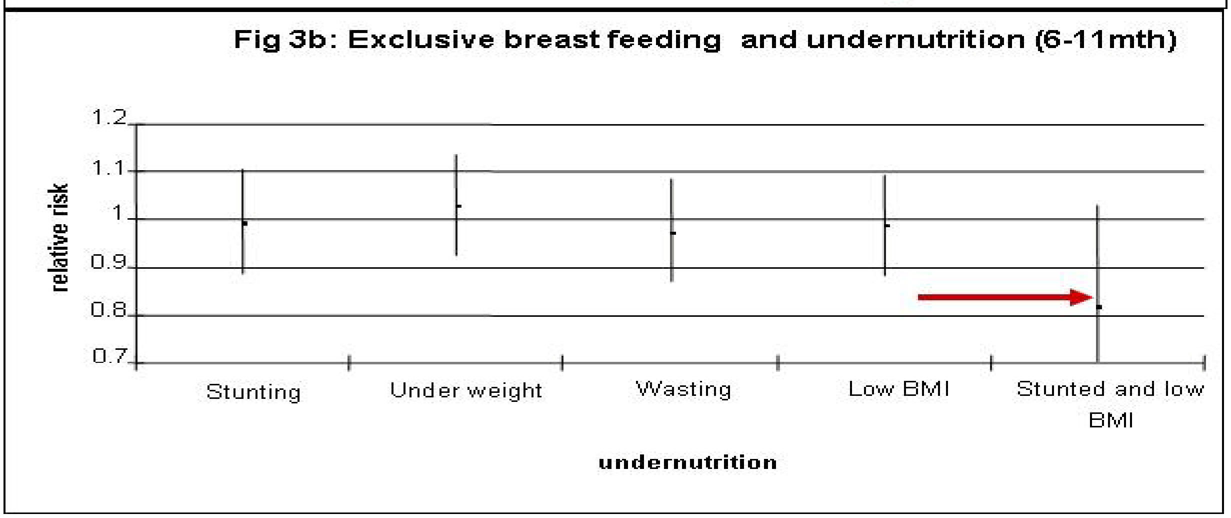
Exclusively breast fed infants weighed more as compared to those receiving additional milk in the first few months. After six months exclusively breast fed infants weigh less than those receiving complementary feeds/household food.



Prevalence of stunting and underweight in relation to age is shown in Figure 2. There was a progressive increase in stunting and underweight between 3-23 months; stunting and underweight rates plateau after the second year.

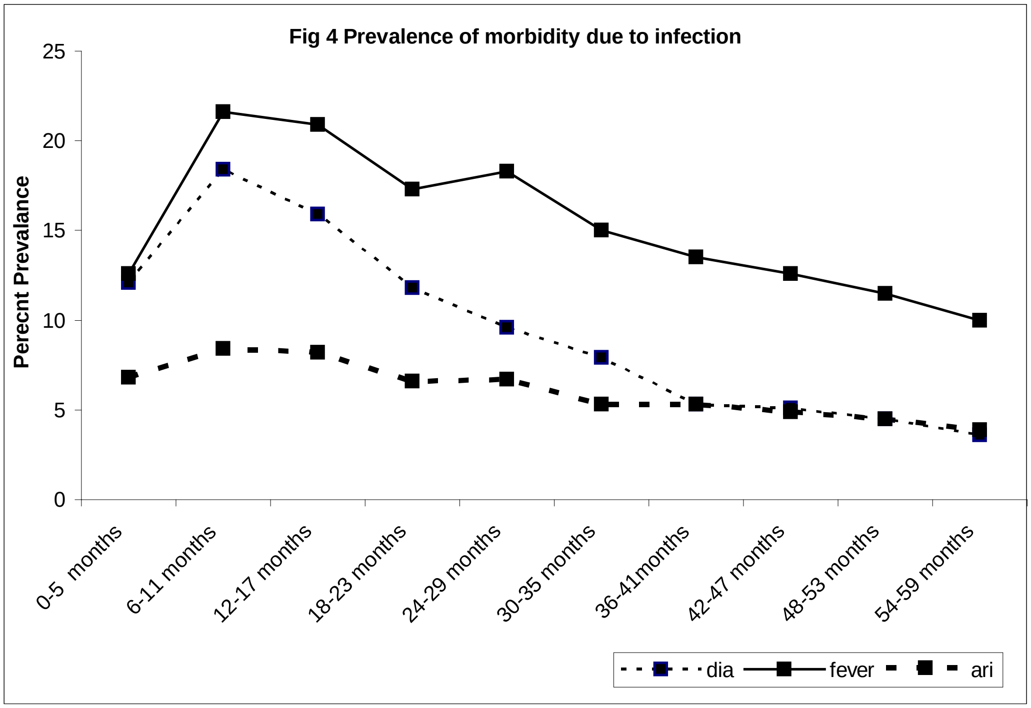
Importance of exclusive breast feeding as critical determinants of infant growth in the first six months of life is globally recognized. Relative risk (with confidence interval) of undernutrition as assessed by the five anthropometric indices was computed in relation to exclusive breast feeding in 0-5 month age group. Risk of underweight, wasting and low BMI was lower in infant in the age group 0-5 months who were exclusively breast-fed (Figure 3a).





Morbidity due to infection

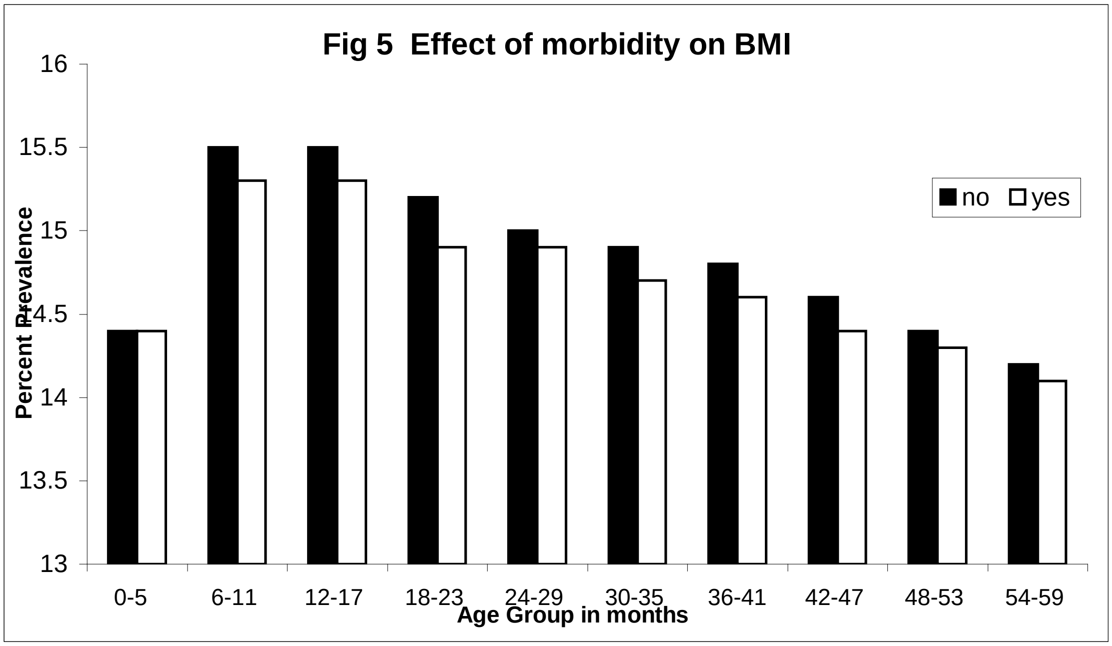
Prevalence of morbidity due to infection in relation to age is shown in Figure-4. Prevalence of morbidity was low in the first 3 months when infants were mostly solely breast-fed and had lower exposure to poor environmental hygiene. There was a progressive increase in prevalence of morbidity due to infections between 3-6 months - perhaps this was due to introduction of foods other than breast milk. After six months there was continued increase in morbidity which might be attributable to introduction of complementary foods and household food which are prone for bacterial contamination due to poor environmental hygiene. Diarrhea was the most common infection; prevalence of diarrhea and fever showed a progressive increase between 3-23 months. Inappropriate, inadequate feeding practices and poor hygiene at home might be the major factors responsible for the rise both in morbidity and undernutrition during later half of infancy. After the first two years there is some reduction in morbidity due to infection.

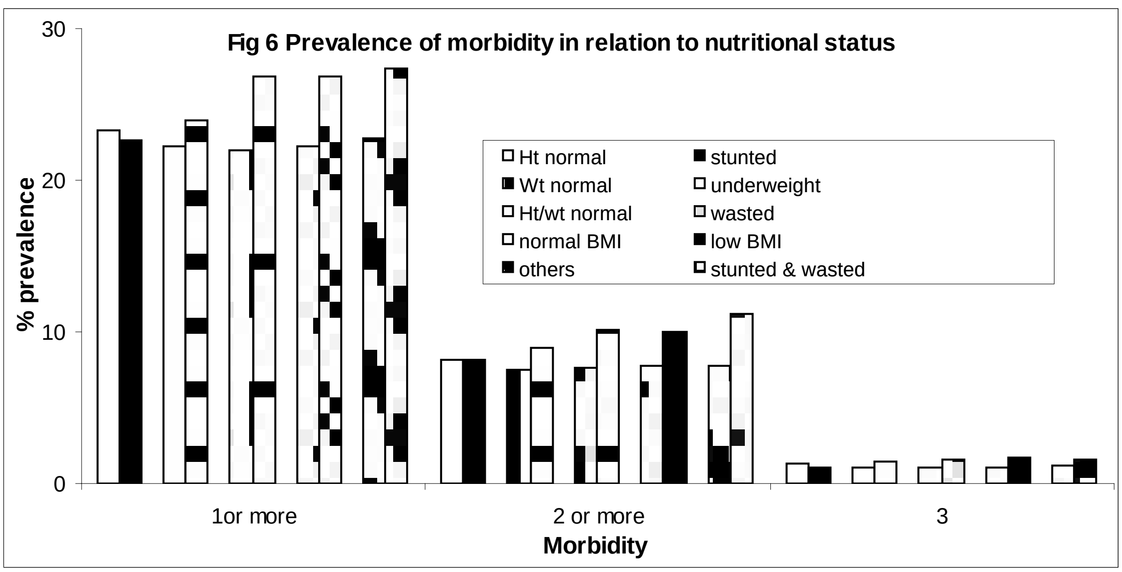


Morbidity and nutritional status

Analysis of data showed that children who had morbidity during the last fortnight had lower mean body weight as compared to those did not have morbidity during that period. There were no significant differences in the mean height between infants and children who had morbidity due to infections in the last fortnight. Children who had morbidity during the last fortnight had lower BMI as compared to those who did not (Figure 5). Prevalence of morbidity due to infection (one or more episodes in the last fortnight) was higher in children who were under weight, wasted, had low BMI or in the small number of children who were stunted and wasted (Figure 6). Analysis of data on prevalence of under-nutrition in relation to number of episodes of morbidity due to infection in the last fortnight showed that underweight, low BMI and wasting rates are higher in children who had more than one morbidity in the last fortnight. Prevalence of under-nutrition as assessed by any parameter is higher in children who had diarrhoea. Underweight, low BMI and wasting are higher in those with fever in the last fortnight.

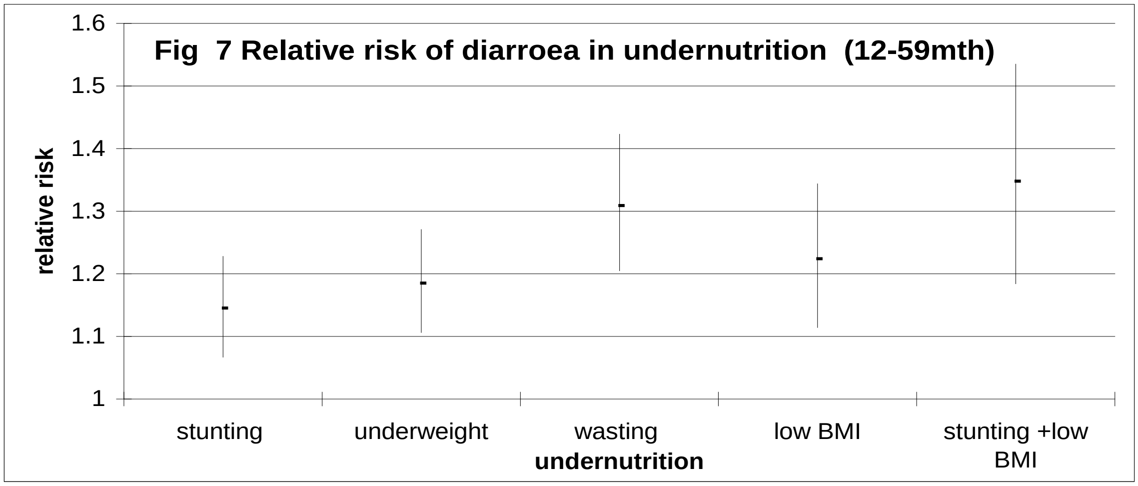
Relative risk of diarrhoea in relation to undernutrition as assessed by different anthropomentric indices in the age group 12-59 months was computed and is presented in Figure 7.





Indices associated with current energy deficiency such as wasting, low BMI and stunting with low BMI were associated with higher risk of diarrhoea (Fig 7).

Relative risk (with CI) of morbidity was computed in relation to different anthropometric indices used for assessment of undernutrition (<-2Sd of the median for the index) and the results are shown in Table-2. Relative risk of morbidity was not high in stunted children perhaps because stunting had occurred earlier and does not have any relationship with the morbidity due to infection which occurred in the last fortnight. Relative risk of morbidity was higher and seen more consistently in children with current energy deficiency which is manifested as wasting, low BMI for age or in the small group of children who were stunted and wasted.



Undernourished children (except those having stunting) were less likely to have no morbidity in the last fortnight as compared to normally nourished children (Table 2).

Table 2 Relative risk of morbidity in relation to undernutrition in preschool children (0-59months)

Morbidity		Stunted	Underweight	Wasted	Low BMI	Stunted and low BMI
One and more	RR	0.967	1.029	1.216	1.213	1.209
	CI	0.935-1.000	1.043-1.116	1.176-1.265	1.163-1.264	1.135-1.287
Two and more	RR	0.983	1.193	1.325	1.291	1.414
	CI	0.919-1.052	1.115-1.277	1.225-1.432	1.188-1.403	1.253-1.596
Three morbidity	RR	0.831	1.404	1.484	1.556	1.321
	CI	0.687-1.006	1.163-1.696	1.197-1.839	1.245-1.945	0.924-1.889
No Morbidity	RR	1.01	0.977	0.939	0.939	0.939
	CI	1.000-1.020	0.967-0.987	0.936-0.952	0.926-0.953	0.917-0.961

Discussion

The importance of infant feeding as the determinant of growth and relative freedom from infections is well recognized. In India, steps taken for the protection and promotion of breast-feeding have been effective and breast-feeding is almost universal; mean duration of lactation is over 2 years. However, the message that exclusive breast-feeding up to six months and gradual introduction of semisolids from six months are critical for the prevention of undernutrition in infancy has not been as effectively communicated.

Analysis of data from NFHS 3 using the WHO 2006 standards indicate that majority of infants in the 0-2 months are exclusively breast fed . Prevalence of under-nutrition in the first three months was about 30%. Exclusive breast feeding by majority of mothers in this period protects the infant from further deterioration in nutritional status (low birth-weight rates in India is about 30%). A small rise in the prevalence of undernutrition between three and six months is likely to be due to too early introduction of milk substitutes and consequent higher morbidity in this period. A further rise in the undernutrition rate between six and twelve months is likely to be due to too late introduction or inadequate amount of complementary feeds to children in this age group as well as increase in morbidity and inadequate care during infections. Further increase in undernutrition between 12-23 months is likely to be due to low energy intake because children are not fed often enough with low energy dense household food (Figure 2) . These data clearly bring out the importance of too early introduction of breast milk substitutes, too late introduction of complementary feeds, too few feeds with household food and poor care during morbidity as major factors associated with rising prevalence of undernutrition in infant and young child.

Computation of relative risk of under-nutrition (as assessed different anthropometric indices) in relation to infant feeding practices in 0-5 and 6-11 months age group showed that exclusive breast-feeding in the first 6 months protects against underweight, wasting and low BMI. Exclusive breast-feeding in 6-11 age groups is associated with higher risk of stunting with low BMI (Figure 3a and 3b). Importance of infant and young child feeding practices as determinants of infant and young child nutrition is well recognized. However the relative risk of undernutrition in relation to feeding practices is rather low. This is most probably due to the multiplicity of factors that influence nutritional status during infancy. The fact that appropriate infant feeding practices protect against current energy deficit as well as infection in infancy could be used as very powerful message in advocacy, awareness building and nutrition education efforts to improve appropriate infant and child feeding practices.

Morbidity due to infection is lowest in the first three months when infants were solely breast fed. Too early introduction of milk substitutes and too late or inadequate complementary food were associated with increased risk of infection. If infections are not detected and treated effectively in the primary health care settings, they will result in undernutrition; severe infection may lead to death. It is computed that exclusive breast-feeding and appropriate complementary feeding will lead to a 20% reduction in IMR[8]. Improvement in infant and young child feeding and caring through coordinated efforts of Integrated Child Development Services and National Rural Health Mission can result in substantial improvement in nutrition and health status and survival during the critical first two years of life.

Analysis of data on association between undernutrition and morbidity due to infections showed that infants and children who had morbidity due to infection in the previous fortnight had lower mean weight and lower mean BMI as compared to those who did not have any morbidity . Prevalence of morbidity due to infection (one or more episodes in the last fortnight) was higher in children who were under-weight, wasted, had low BMI or in the small number of children who were stunted and wasted.

Computation of relative risk of morbidity due to infection in relation to undernutrition as assessed by weight for age, height for age, BMI for age, wasting, stunting with low BMI showed that prevalence of morbidity due to infection (one or more episodes in the last fortnight) was higher in children who were under-weight, wasted, have low BMI or in the small number of children who were stunted and wasted. Relative risk of morbidity due to any infection is higher in children with current energy deficiency manifested as wasting, low BMI or stunting and low BMI (Table – 2) .These data indicate that under-nutrition as assessed by wasting and low BMI for age is more consistently associated with infection in preschool children. Under-nutrition (low BMI) could be the cause (increased susceptibility to infections) or effect (increased nutrient requirement and greater nutrient loss) of infection.

The association between anthropometric indices of current energy deficit and increased risk of morbidity indicate the urgent need for two interventions : screen for and correct current energy deficit through appropriate nutrition education/ supplementary feeding; promptly and effectively treat infections through appropriate primary health care in order to reduce the nutritional toll of infections. Both these interventions can be effectively implemented through convergence and coordination between the functionaries of Integrated Child Development Services and National Rural Health Mission.

International Obesity Tasks Force has recommended that Body Mass Index for age (BMI in kg/m^2) be used for assessment of overweight/ fatness in children and adolescents[8]. The WHO (2006 and 2007) has provided the standards for BMI in children and adolescents for use by member countries for detection of both under and over nutrition. While BMI for age has been widely used for detection of over weight /obesity in India and other developing countries, BMI for age has not been used widely for assessment of under-nutrition in children even in hospital setting where height measurements and computation of BMI are not difficult. This might at least in part be because of lack publications indicating that BMI of age is a useful indicator for assessment of risk functional decompensation (increased susceptibility to infection) associated with undernutrition. Data from the present analysis indicate that that low BMI-for-age and wasting which take into account the weight for height have a more consistent association with infection in Indian preschool children as compared to weight for age.

It is hoped that this finding from secondary data analysis will pave way to research studies with primary data collection exploring the usefulness of BMI for age for assessment of risk of infections as compared to weight for age. If the findings of the present study are confirmed by other studies it might lead to as the wider use of this BMI for age for assessment of undernutrition in clinical settings and surveys in India. This in turn might lead to increasing use of a single indicator (BMI for age) for assessment of both under and overnutrition. In view of the known high stunting rates in Indian children, use of BMI-for-age for monitoring nutritional status children might help in early detection of children having low or high BMI and effective management of both under and overnutrition; such interventions could result in reduction in the immediate risk of morbidity due to infections and long term risk of non-communicable diseases.

The demonstration of association between current energy deficit and morbidity may have policy and programme implications also. In India only about one fifth of the children have low BMI-for-age; it might therefore be possible to focus the attention on detection of under-nutrition (low BMI) and correction through increase in dietary intake under programme conditions. Early detection and correction of low BMI might reduce the risk of infection and also enable the child to continue in its growth trajectory for weight and height. Nearly one third of preschool children suffer from morbidity due to infections; early detection and treatment of infections through primary health care may go a long way in preventing deterioration in nutritional status of children.

Acknowledgement

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Assessment of nutritional status in Indian preschool children using WHO 2006 growth standards

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Introduction

The World Health Organisation (WHO) Child Growth Standard for infants and children up to the age of 5 years was published in April 2006. It was based on a multi-country study (Brazil, Ghana, India, Norway, Oman and USA) undertaken between 1997 and 2003 on growth of healthy breast-fed children under optimal conditions[1-4]. The release of these new standards evoked a lot of interest. Some of the developed countries such as UK and USA, examined the usefulness of these growth standards for assessment of nutritional status vis a vis existing national standards [5-7]. They reported that the major advantages for using WHO standards in developed countries are that they

- Pertain to growth pattern of breast fed infants and could be used as a tool to promote breast feeding and
- Can result in better detection of over-nutrition in early infancy and childhood.

Other publications have explored the usefulness of BMI for age from WHO standards for assessment of severe undernutrition during relief operations[8-10.] One recent publication explored the extent to which the use of the WHO 2006 standards affect the estimated prevalence of undernutrition in low and middle income countries[11].

India is a population billionaire with high under-nutrition rates in preschool children. Majority of Indian children are breast fed and therefore WHO standard based on growth of breast fed infants might be appropriate for assessment of nutritional status of Indian children. Implications of the use of WHO growth standards for weight for age for assessment of undernutrition vis a vis other standard currently use in health services/surveys and Integrated Child Development Services Programme in India have been reported[12,13]. In India weight for age has been the most widely used indicator for assessment of nutritional status, detection of undernutrition and monitoring the improvement following interventions. The question whether in Indian children with high stunting rates, weight for age is the appropriate indicator for assessment of under nutrition is often debated among nutrition scientists in the country. While there is global acceptance that body mass index should be used for assessment of obesity /adiposity in children[14], there has not been a similar consensus regarding use of BMI for assessment of undernutrition in children. So far there have not been any publications comparing growth of Indian children with the WHO (2006 standards) and assessing the prevalence undernutrition in Indian preschool children, using the WHO 2006 standards for height, weight and BMI for age

Material and methods

The National Family Health Survey-3 database provides the following information in about 56, 438 preschool children: age, sex, weight, height, infant and young child feeding practices and morbidity due to infections in the last fortnight. Data from NFHS 3 were obtained and analysed. Data on two factors that influence nutritional status namely infant feeding practices and prevalence of morbidity in these children were computed. Height, weight and BMI for age of these Indian preschool children in relation to age were computed using LMS soft ware and were compared with the WHO (2006) standards. Using the WHO (2006) standards, prevalence of under-nutrition in relation to age as assessed by four anthropometric indices - weight for age, height for age, BMI for age , wasting were computed.

Results

The number of children available for analysis from the NFHS-3 database is shown in Table -1. There were 45377 infants and children with age, sex, infant feeding practices, morbidity due to infections in the last fortnight, height and weight (within the valid range). Age distribution of these children is shown in Table -2.

Table 1: **The study population**

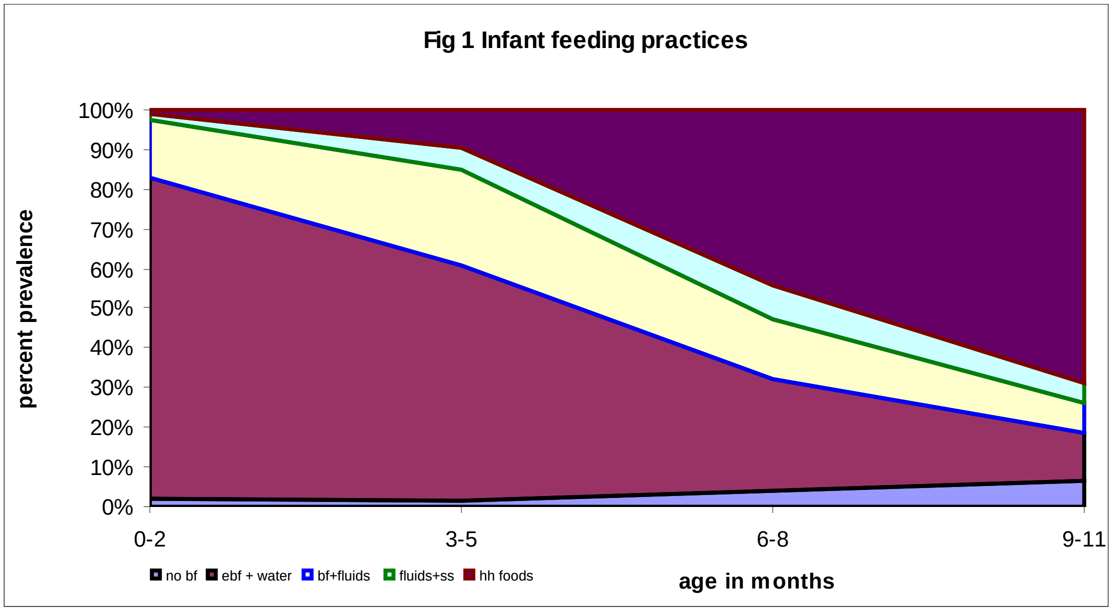
Total number of children surveyed	56438
No. of children with valid age (0-59 months):	52868
No. of children with valid weight (within range)	45377
No. of children with valid height (within range)	45377
Children with valid age, height, and weight:	
Male	23724
Female	21653

Table 2 : Age of the children

Age Group in Months	No. of children	Percentage
0-2	1484	3.3
3-5	2308	5.1
6-8	2545	5.6
9-11	2062	4.5
12-17	4583	10.1
18-23	4561	10.1
24-29	4680	10.3
30-35	4378	9.6
36-47	9396	20.7
48-59	9380	20.7
Total (0-59)	45377	100.0

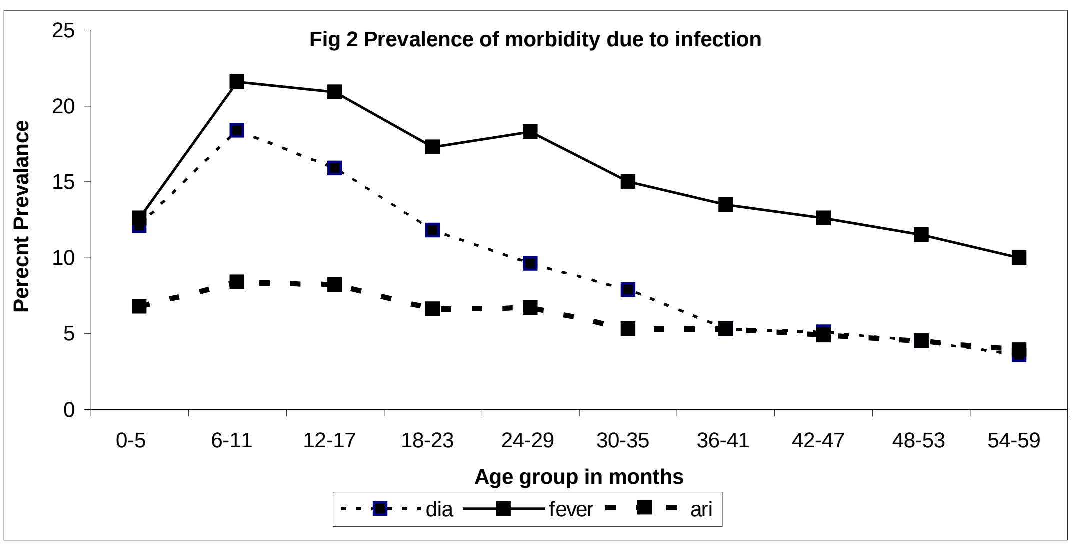
Infant and young child feeding practices

In India breast-feeding was nearly universal; however less than 50 % of infants were exclusively breast fed up to six months; many received animal milk from about three months of age. Most of the infants over six months of age continued to be breast fed and were also given modified household food (Figure 1). Very few infants received adequate quantities of appropriate energy dense complementary food from 6 months. Most of the children continued to be breast fed between 12-23 months (median duration of breast feeding was 24 months) and also received to predominantly cereal pulse based household food with low energy density.



Prevalence of morbidity due to infections

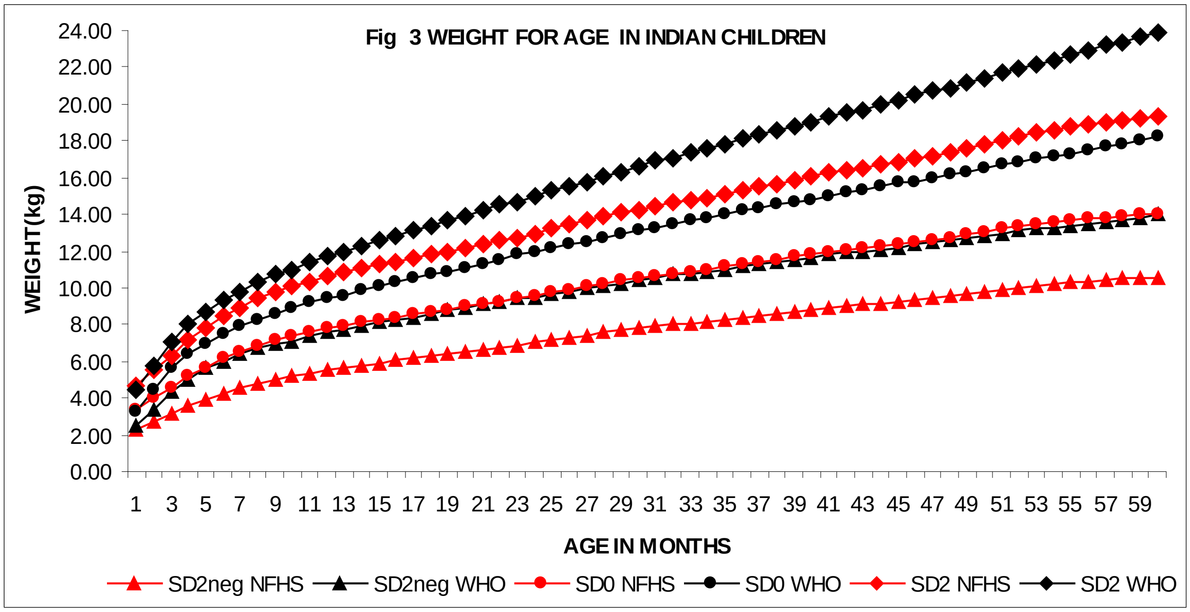
Prevalence of morbidity due to infection in relation to age is shown in Figure-2.



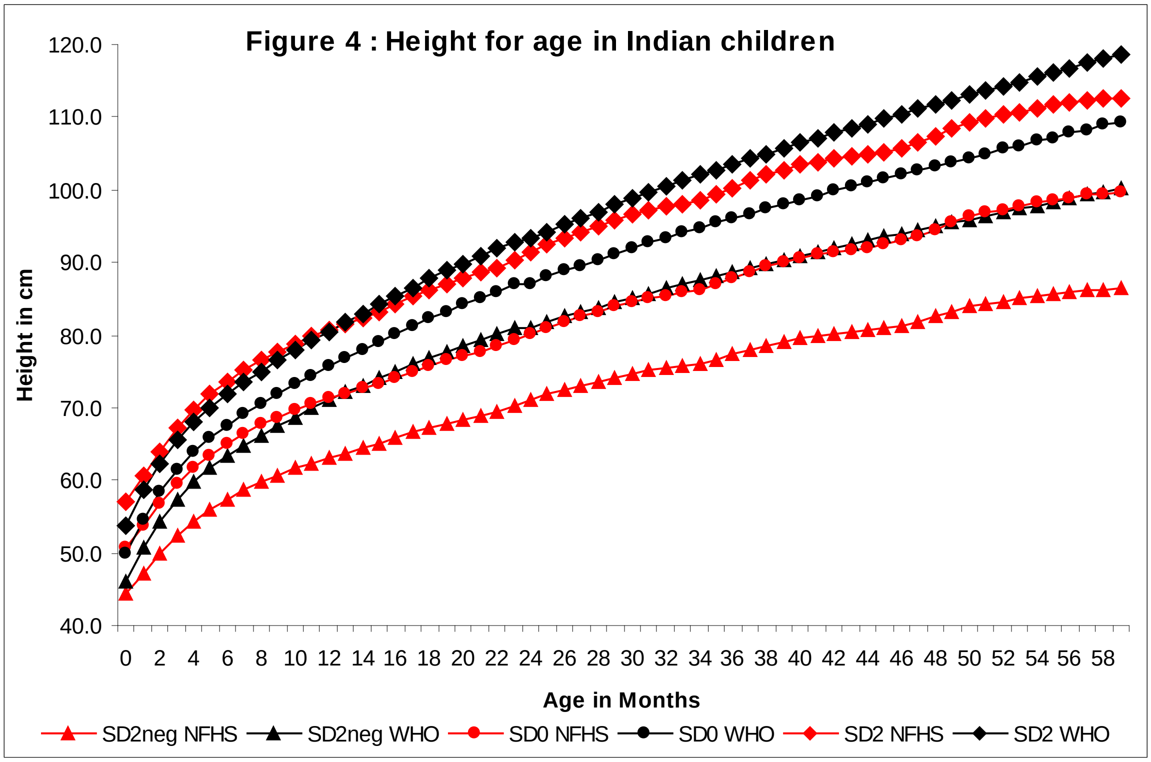
Prevalence of morbidity was low in the first 3 months when infants were mostly solely breast-fed and had lower exposure to poor environmental hygiene. There was an increase in prevalence of morbidity due to infections between 3-5 months - perhaps due to introduction of foods other than breast milk. Between 6-23 four months there was progressive increase in morbidity which might be attributable to introduction of complementary foods and household food which are prone for bacterial contamination due to poor environmental hygiene. Diarrhea was the most common infection; prevalence of diarrhea and fever showed a progressive increase between 3-23 months. After 24 months there was a reduction in the prevalence of morbidities due to infections.

Growth of Indian children

Weight for age of Indian children covered under NFHS surveys were compared with the WHO (2006) standards (Figure 3). In the first month after birth, the weight of Indian children was just lower than the corresponding values of WHO standards. By six months the median values of Indian children corresponded to the <-2SD of the WHO standard. From 12 months onwards the median weight for age of Indian children is just below the -2SD of WHO standards. The -2SD values of Indian children which was just below the corresponding values of the WHO standards in the first months, showed a reduction over the next six months and thereafter fell to values well below but parallel to -2SD values of the WHO standards. The +2SD value of Indian children was similar to the corresponding values of the WHO standards in the first month but subsequently the values for Indian children were lower and by six months lie just above the median values of WHO standards. There after the +2SD values for Indian children were just above and parallel to the median values for WHO standards for weight for age.

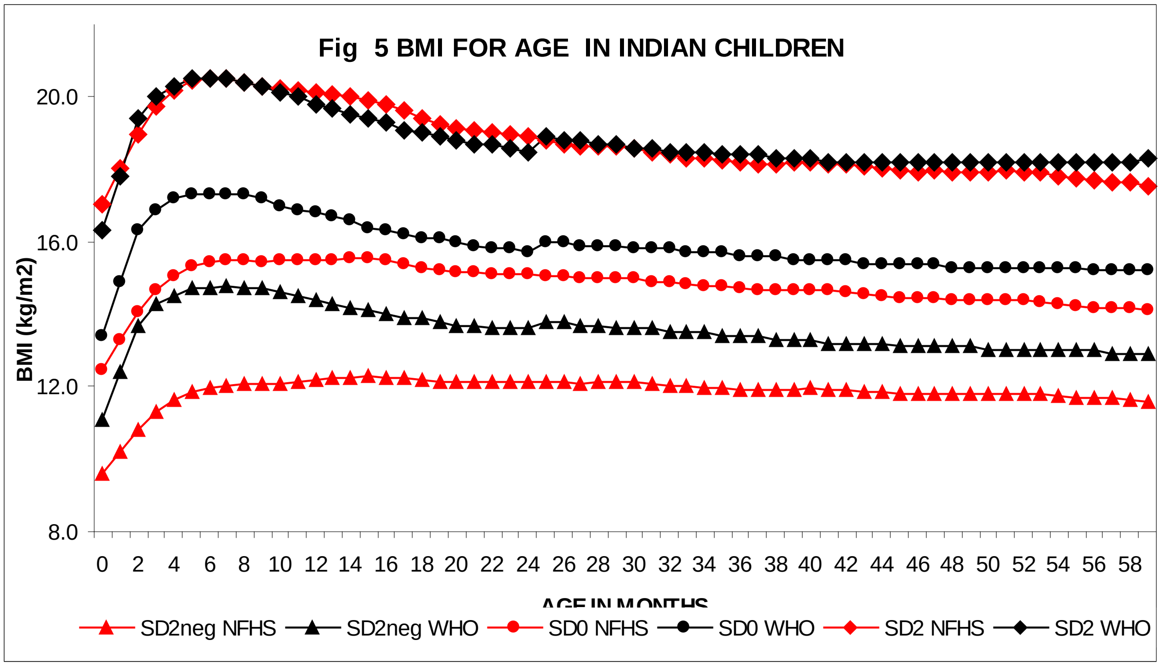


Comparison of the height for age of Indian children and the WHO standards for height for age is shown in Figure 4.



In the first month after birth, the median and -2SD height for age of Indian children were just lower than the corresponding values of WHO standards; the +2SD height for age of Indian children was higher than the corresponding value of WHO standards. Between 1-12 months there was a progressive fall in the median height for age values in Indian children as compared to the WHO standards. From 12 months onwards the median values of height for age in Indian children was essentially similar to the -2SD values of WHO standards. The -2SD values for Indian children was below the corresponding values of the WHO standards at one month. There was a progressive reduction in the -2SD values for height for age in Indian children as compared to the WHO standards; gap between -2SD values for Indian children and -2SD values of the WHO standards was 3cm at first month, 8cm at 12 months and nearly 14cm at 59 months. The +2Sd values for Indian children which were above the corresponding values of the WHO standards progressively declined so that at 12 months they were similar to the WHO standards; the reduction continued between 12-59 months so that at 59 months, the gap between +2SD value of Indian children and corresponding value of the WHO standards was 6cm.

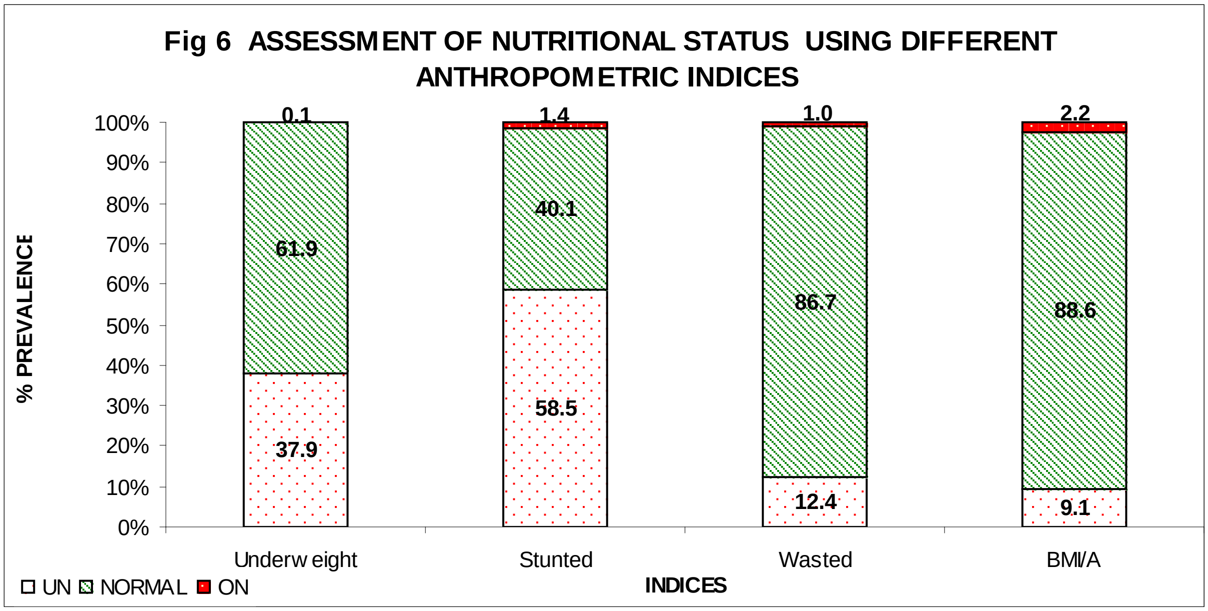
Comparison between the BMI for age of Indian children and the WHO standards is given Figure 5.



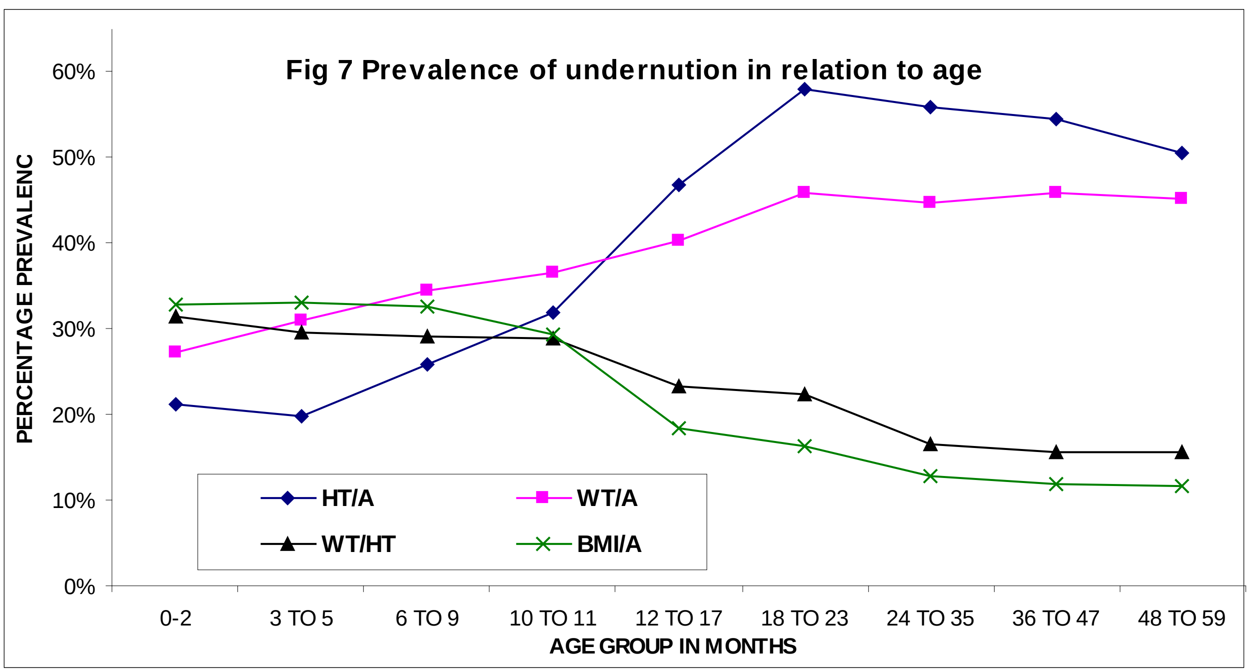
In the first month after birth, the median and -2SD values for BMI of Indian children are lower than the corresponding values of WHO standards; the +2SD values for Indian children are higher than the corresponding values of WHO standards. By three months the median of Indian children was just above the -2SD of the WHO standards. Subsequently the gap between median value of BMI for age for Indian children and -2SD values of the WHO (2006) widened; between 18 months and 59 months the difference between the median BMI values of Indian children and the WHO standards was about 0.8. Through out the 0-59 months the -2SD values of the Indian children were lower than the - 2SD values of the WHO standards. There was a widening of the gap between -2SD values of Indian children and the corresponding values of the WHO standards between 1- 6 months; this gap narrowed between 6-18 months and thereafter remained unaltered. The +2 SD values of Indian children were essentially similar to the +2SD values for WHO standards.

Prevalence of undernutrition

Prevalence of undernutrition (<-2SD) as assessed by weight for age, height for age , BMI for age and wasting for under five children is shown in Figure 6. These data indicate that stunting is the most common manifestation (58.5%) of undernutrition in these children; 37.9% of children were underweight. In contrast only 9.1% were undernourished if BMI for age is used as the criterion for assessment of undernutrition. It is noteworthy that if BMI for age is used as the indicator 2.2% of these children were overnourished. These data indicate that BMI for age is a useful indicator for assessment of over and undernutrition among children belonging to communities with high stunting rates.



Changes in prevalence of under-nutrition in relation to age of the child as assessed WHO standards for weight for age, height for age, wasting and BMI for age is shown in Fig 7.



Underweight rates

In India about 30% of infants weigh less than 2.5 kg at birth. Underweight rates in the first 3 months remained similar to low birth-weight rates. There was a progressive increase in underweight rates between 3 to 24 months. Under weight rates remained unaltered between 2- 5 years of age.

Stunting rates

In the first six months the stunting rates remained similar to the stunting rates reported at birth. Stunting rates show a steep and progressive increase from 20% during the first six months to 58 % in the 18-23 month age group. Over the next three years there is 7% reduction in stunting rate.

BMI for age and wasting

Low BMI for age and wasting rates were highest in the first six months. During this period underweight rates were higher than the stunting rates; therefore BMI and wasting rates (which is ratio of weight for a given height) was high. After six months, stunting rates go up substantially; steeper increase in stunting rates as compared to underweight rates resulted in reduction in wasting / low BMI rates. This reduction in low BMI and wasting rates with increasing age of the child should not be interpreted as improvement in nutritional status. Comparison of BMI for age and weight for height indicate that BMI is the better indicator for detection of undernutrition in infants (Table 4)

Table 4:Comparison of BMI for age with weight for height for detection of under-nutrition in infants

(N)	<-2SD	>-2SD	
BMI for age	2695	5724	8419
Wt/Ht	2490	5929	8419
Total	5185	10653	16838
chi square test p <0.01			

Discussion

One third of the Indian infants are born with birth-weight below 2500g (LBW); these infants start their life with high low birth-weight, stunting and wasting rates. Maternal factors associated with LBW such as low maternal height and low pre-pregnancy weight cannot be modified during pregnancy. However universal access to antenatal care will result in early detection and effective management of low pregnancy weight gain, maternal anaemia, and pregnancy induced hypertension and bring about some reduction in LBW. Improving coverage, content and quality of antenatal care would be an important intervention for reducing undernutrition in preschool children in India.

During the first few months Indian children who are exclusively breast fed and are relatively free from infections; as a result there is no further increase in underweight and stunting rates. These finding can be used to mount effective campaign for exclusive breast feeding during the first six months for prevention of undernutrition in early infancy. Introduction of animal milk between 3-5 months results reduction in breast milk secretion due to reduction in suckling stimulus, increase in morbidity due to infections in infants and an increase in underweight rates. A further rise in underweight and stunting rates occur between 6-11 months due to late introduction, inadequate quantity and low calorie density of complementary feeds and increase in morbidity due to infections. Inadequate food intake because children are not fed often enough with the low calorie dense household diets in the first year is the cause of increase in the underweight and stunting rates between 12-23 months. Thus use of WHO 2006 standards for assessment of underweight/stunted children clearly brings out the importance of too early introduction of breast milk substitutes, too late introduction of complementary feeds, poor young child feeding practices and high morbidity rates due to infections as major factors associated with increase in underweight/stunting rates in infants and young children. These is data can used for advocacy and awareness building for two critical interventions to improve nutritional status of young children, namely

- nutrition education to ensure appropriate infant and child feeding practices and
- Health education to improve timely access to health care.

Convergence of services under National Rural Health Mission and Integrated Child Development Services can improve access to both nutrition education and health care in India and bring about improvement both in the health and nutritional status of preschool children.

Over the last five decades India has witnessed substantial improvement in per capita income, reduction poverty, improved household food security, access to health and nutrition services; however decline in underweight rates has been slow. The reasons why socioeconomic development and national food security have not been translated into concomitant and commensurate reduction in underweight rates in Indian children are not clear. Prevalence of underweight rates in Indian preschool children is higher than underweight rates in sub-Saharan Africa; however under five mortality rates in India are far lower than the Sub-saharan Africa (Table -3)[15] – the so called South Asian enigma[16]. Importance of low birth weight (LBW) as determinant of undernutrition (wasting) in preschool children has been demonstrated but contribution of LBW to wasting varied. LBW, measles and access to safe water supply explained 64% of variability in wasting in Asia. In Latin America, LBW and survey year explained 38%; in Africa, LBW, survey year, and adult literacy explained only 7% of the variability in wasting [17]. Low birth weight can be either due to preterm birth, intrauterine growth retardation or both [18,19]. Preterm low birth weight babies require intensive care and if this is not available, neonatal and infant mortality rates are high[19]. It is well recognized that there are huge differences in prevalence of low birthweight between different regions of the world [20] . Ethnic differences in birthweight, gestational age and neonatal mortality has been well documented in USA[21,22] . It is possible the South Asian enigma is mainly due to the differences in rates of preterm births and mature low birthweight neonates between Asia and Sub Saharan Africa. Majority of Indian low birth weight infants were born at term and survived if essential new born care was provided[23]. Birth weight was a major determinant of growth in childhood; mature low birth-weight children had a lower growth trajectory as compared to children with normal birth weight[24]. In Sub Saharan Africa preterm births constitute most of the low birthweight neonates; neonatal and infant mortality rates are high due to lack of access to adequate health care. The high U5 MR and undernutrition in the predominantly normal birthweight survivors might be due to low dietary intake and poor access to health care. Further studies are needed to explore this hypothesis.

Low BMI for age and wasting rates are highest in the first six months. During this period underweight rates are higher than the stunting rates; therefore low BMI and wasting rates (which are ratios of weight for height) are high. After the first three months, there is a progressive rise in the stunting and underweight rates due to poor infant/ young child feeding/ caring practices and increase in morbidity due to infections. As the increase in stunting rates are higher than the increase in underweight rates, there is a slow but steady decline in the wasting and low BMI rates. This should not be interpreted as improvement in nutritional status but the result of stunting which is an adaptation to chronic energy deficit.

Nutrition scientists and pediatricians recognize that the impact of energy deficit on anthropometric indices of nutritional status varies depending upon the duration of the deficit. Initially the response is wasting; if energy deficit is quickly corrected, wasting is reversed and the linear growth of children continues normally. If however the energy deficit persists, there is growth retardation and stunting occurs; these stunted children may have normal BMI for their height. If food intake is inadequate even to meet the requirement of the stunted child, the child develops wasting and the vicious cycle of wasting and stunting continue (Figure 8). Low BMI is a sensitive indicator of current energy deficit; early detection of energy deficit using BMI for age and expeditious correction of it is likely to be the most effective intervention for preventing stunting. Prevention of stunting in the first two years of life is important, because once stunting has occurred, it may not readily reversible; stunting in the first two years may be associated not only with low adult height but may also be a factor especially in women for lower birth weight in their off springs – the trans-generational impact of childhood undernutrition[25] .

India and many developing countries are currently in the midst of socioeconomic, demographic, nutritional and epidemiological transition; undernutrition continues to affect large segments of the population but overnutrition and obesity are emerging as public health problems especially among urban affluent segments of population. Data from the present study indicate that BMI is a sensitive indicator for detection of overnutrition (Fig 6) in this population with high stunting rates. Wider use of BMI for age for early detection and correction of current energy deficit /excess can prevent both further stunting and overnutrition. This is especially important in India because recent studies have shown that undernutrition in early childhood followed by rapid improvement body mass index in early/ late childhood/ adolescence may predispose to overnutrition and non-communicable disease risk in early adult life[26].

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Annexure -2

Table 1 Relative risk of morbidity among under nourished children (0-5 months, 6-11 months and 12-59 months)

	0-5 months			6-11 months			12-59 months		
Types of morbidity	**RR**	**CI**		**RR**	**CI**		**RR**	**CI**	
		Lower limit	**Upper limit**		**Lower limit**	**Upper limit**		**Lower limit**	**Upper limit**
For stunting									
Diarrhoea	*1.225*	1.002	1.496	*0.915*	0.798	1.050	*1.145*	1.067	1.228
Fever	*1.316*	1.088	1.592	*1.011*	0.896	1.142	*0.977*	0.931	1.026
ARI	*1.491*	1.149	1.934	*0.911*	0.733	1.130	*0.997*	0.917	1.083
For under weight									
Diarrhoea	*1.295*	1.082	1.550	*1.033*	0.911	1.171	*1.185*	1.106	1.271
Fever	*1.417*	1.193	1.683	*1.053*	0.940	1.180	*1.137*	1.083	1.194
ARI	*1.026*	0.794	1.325	*1.043*	0.853	1.271	*1.105*	1.016	1.201
For wasting									
Diarrhoea	*1.315*	1.101	1.570	*1.166*	1.026	1.326	*1.309*	1.205	1.423
Fever	*1.315*	1.107	1.564	*1.040*	0.923	1.172	*1.223*	1.153	1.298
ARI	*0.920*	0.710	1.192	*1.025*	0.832	1.263	*1.056*	0.949	1.175
For BMI (<-2SD)									
Diarrhoea	*1.317*	1.106	1.570	*1.164*	1.026	1321	*1.224*	1.114	1.344
Fever	*1.380*	1.164	1.635	*1.040*	0.925	1.170	*1.174*	1.098	1.254
ARI	*0.883*	0.684	1.141	*1.001*	0.816	1.229	*0.996*	0.882	1.125
For stunted and <-2SD BMI									
Diarrhoea	*1.666*	1.280	2.168	*0.931*	0.746	1.162	*1.348*	1.184	1.535
Fever	*1.787*	1.396	2.288	*1.097*	0.912	1.320	*1.193*	1.084	1.313
ARI	*1.291*	0.857	1.944	*1.139*	0.828	1.566	*1.059*	0.889	1.261

Source: Computed from NFHS-3, 2005-06 data files.

Table 2 Relative risk of morbidity among under nourished children (0-5 months, 6-11 months and 12-59 months)

	12-17 months			18-23 months			24-29 months		
Types of morbidity	**RR**	**CI**		**RR**	**CI**		**RR**	**CI**	
		Lower limit	**Upper limit**		**Lower limit**	**Upper limit**		**Lower limit**	**Upper limit**
For stunting									
Diarrhoea	*1.182*	1.035	1.351	*1.134*	0.964	1.336	*1.242*	1.038	1.486
Fever	*0.905*	0.807	1.013	*1.044*	0.917	1.188	*1.105*	0.977	1.248
ARI	*0.971*	0.799	1.180	*0.952*	0.762	1.188	*0.904*	0.731	1.119
For under weight									
Diarrhoea	*1.183*	1.035	1.353	*1.425*	1.215	1.672	*1.204*	1.010	1.435
Fever	*1.209*	1.080	1.354	*1.157*	1.019	1.314	*1.247*	1.105	1.407
ARI	*1.267*	1.043	1.539	*1.070*	0.859	1.333	*0.968*	0.781	1.201
For wasting									
Diarrhoea	*0.910*	0.774	1.070	*1.517*	1.279	1.798	*1.356*	1.097	1.676
Fever	*1.211*	1.069	1.373	*1.302*	1.131	1.499	*1.313*	1.134	1.519
ARI	*1.079*	0.862	1.350	*0.989*	0.759	1.288	*0.899*	0.668	1.210
For BMI (<-2SD)									
Diarrhoea	0.920	0.771	1.098	*1.324*	1.091	1.607	*1.157*	0.904	1.481
Fever	*1.100*	0.957	1.264	*1.278*	1.094	1.494	*1.626*	1.073	1.485
ARI	*0.878*	0.677	1.139	*0.952*	0.704	1.287	*0.900*	0.645	1.254
For stunted and <-2SD BMI									
Diarrhoea	*1.063*	0.836	1.353	*1.205*	0.930	1.561	*1.181*	0.833	1.674
Fever	*0.921*	0.739	1.147	*1.406*	1.161	1.702	*1.085*	0.840	1.393
ARI	*0.879*	0.599	1.291	*0.885*	0.586	1.337	*0.936*	0.583	1.502

Source: Computed from NFHS-3, 2005-06 data files.

Table 3 Relative risk of morbidity among under nourished children (0-5 months, 6-11 months and 12-59 months)

	30-35 months			**36-47 months**			**48-59 months**		
Types of morbidity	**RR**	**CI**		**RR**	**CI**		**RR**	**CI**	
		Lower limit	**Upper limit**		**Lower limit**	**Upper limit**		**Lower limit**	**Upper limit**
For stunting									
Diarrhoea	*1.209*	0.980	1.492	*1.130*	0.949	1.345	*1.035*	0.850	1.261
Fever	*1.028*	0.890	1.187	*0.848*	0.764	0.942	*1.051*	0.935	1.181
ARI	*1.396*	1.069	1.821	*0.925*	0.777	1.101	*1.080*	0.890	1.309
For under weight									
Diarrhoea	*1.207*	0.985	1.478	*1.088*	0.915	1.293	*1.214*	0.997	1.478
Fever	*1.256*	1.090	1.447	*1.010*	0.909	1.121	*1.132*	1.008	1.272
ARI	*1.587*	1.229	2.050	*1.043*	0.901	1.271	*0.991*	0.816	1.203
For wasting									
Diarrhoea	*1.236*	0.964	1.586	*1.240*	0.995	1.544	*1.144*	0.884	1.480
Fever	*1.218*	1.024	1.448	*1.062*	0.923	1.221	*1.030*	0.880	1.206
ARI	*1.322*	0.976	1.791	*0.936*	0.732	1.197	*0.998*	0.758	1.288
For BMI (<-2SD)									
Diarrhoea	*0.913*	0.667	1.250	*1.291*	1.015	1.643	*1.222*	0.922	1.618
Fever	*1.065*	0.867	1.307	*1.125*	0.966	1.311	*0.948*	0.789	1.140
ARI	*1.209*	0.853	1.714	*1.034*	0.793	1.348	*0.876*	0.640	1.199
For stunted and <-2SD BMI									
Diarrhoea	*1.207*	0.819	1.778	*1.017*	1.017	2.028	*1.216*	0.776	1.908
Fever	*1.165*	0.887	1.531	*1.166*	0.928	1.466	*1.049*	0.789	1.394
ARI	*1.560*	1.014	2.402	*0.802*	0.506	1.272	*1.356*	0.893	2.059

Source: Computed from NFHS-3, 2005-06 data files.

Table -4 Logistic Regression results of socio-economic-demographic-nutritional and environmental factors on morbidity among children 0-5 and 6-11 months

Background characteristics	Types of morbidity					
	Diarrhoea		Fever		ARI	
	Exp (B)		Exp (B)		Exp (B)	
	0-5 months	6-11 months	0-5 months	6-11 months	0-5 months	6-11 months
Region						
South@						
North	1.735***	1.280	0.804	0.870	1 .585**	1.190
Central	0.939	1.177	0.864	1.087	1.337	1.480**
East	0.797	1.103	1.308*	1.415***	1.013	1.612***
North-east	0.675	0.751	1.223	1.005	0.622	1.632
West	1.545**	1.243	0.800	0.957	1.166	0.710
Place of residence						
Urban @						
Rural	1.075	1.085	0.904	1.032	0.907	0.926
Wealth Index						
Richest @						
Poor	0.987	0.942	1.035	0.748**	1.362	1.086
Poorer	0.805	0.96	1.142	1.089	1.262	1.361*
Middle	1.093	1.120	1.051	1.030	1.209	0.862
Richer	1.206	1.226	1.004	1.238*	0.638*	1.184
Education of mother						
Secondary and above @						
Illiterate	1.281*	1.035	1.017	0.958	1.454	0.881
Primary	1.034	1.098	1.061	1.078	0.777	0.988
Age of mother (in years)						
20-24@						
15-19	0.860	1.325*	1.107	1.306*	2.650***	1.589**
25-29	1.107	0.824	1.050	0.869	1.091	0.896
30-35	0.979	1.103	1.190	1.118	0.760	1.129
35 and above	1.020	1.012	0.834	0.838	0.354	0.571
Birth order of the child						
2-3 @						
1st	0.925	0.942	1.130	1.040	0.696*	1.157
4 and above	1.203	1.038	0.918	0.988	1.154	0.866
Infant feeding practices						
Exclusively breast milk@		0.987				
Breast milk and other food$	1.130		1.019	0.898	0.984	0.970
Quality of water						
Improved@						
Not-improved	0.939	0.865	0.873	1.015	0.950	1003
Quality of cooking fuel						
Improved@						
Not-improved	1.002	0.799**	1.041	1.090	1.204	1.121
Toilet Facilities						
Improved@						
Not-improved	1.063	1.056	0.961	0.997	0.837	0.870
Crowing in household						
Below 3 person@						
3-6 person	NA	NA	NA	NA	1.147	1.049
6 and above	NA	NA	NA	NA	0.909	1.046
Nutrional status						
Normal height for age@						
Stunted	1.056	0.996	1.028	0.984	1.227	0.846
Normal weight for age@						
Under weight	1.100	0.964	1.084	1.019	0.917	1.016
Normal weight for height@						
Wasted	1.235	1.041	1.163	1.045	1.182	1.133
Normal BMI@						
Low BMI	0.917	1.128	0.977	0.962	0.808	0.803
Normal height and BMI@						
Stunted and low BMI	1.289	0.863	1.275	1.001	1.170	1.171
-2 log likelihood	2671.401	4338.436	2801.576	4724.700	1801.291	2516.789
R^2 Nagelkarke	0.054	0.028	0.033	0.030	0.059	0.067
Total No. of children	3790	4606	3790	4606	3790	4606

Source: Computed from NFHS-3 data files.

Note: @: reference category. *: 10% significant level, **: 5% significant level, ***: 1% significant level.

Table 5: Logistic Regression results of socio-economic-demographic and environmental factors on under nutrition among children 0-5 months

Background characteristics	Types of under nutrition				
	Height for age	Weight for age	Weight for height	BMI for age	Height and BMI for age
	Exp (B)	Exp (B)	Exp (B)	Exp (B)	Exp (B)
Region					
South@					
North	0.874	0.787	0.877	0.861	0.722
Central	1.012	1.371***	1.559***	1.602***	1.469**
East	0.940	1.146	1.292**	1.170	1.036
North-east	1.317	0.991	0.812	0.956	1.354
West	0.919	0.877	0.756	0.763	0.856
Place of residence					
Urban @					
Rural	0.828**	0.931	0.971	0.962	0.852
Wealth Index					
Richest @					
Poor	1.294*	1.330**	1.006	1.173	1.433
Poorer	1.170	1.483***	1.051	1.098	1.108
Middle	1.080	1.145	1.010	1.142	1.252
Richer	0.810	0.919	1.084	1.032	1.015
Education of mother					
Secondary and above @					
Illiterate	0.843	0.872	1.226	1.118	0.800
Primary	1.223	1.089	0.722	0.798	1.085
Age of mother (in years)					
20-24@					
15-19	1.326	1.162	0.956	1.021	1.146
25-29	0.888	0.902	0.960	0.885	0.761
30-35	1.047	1.101	1.013	1.117	1.045
35 and above	0.895	0.999	1.068	0.914	1.153
Birth order of the child					
2-3 @					
1^{st}	1.015	1.027	0.878	0.932	1.046
4 and above	1.005	1.003	1.117	1.122	1.070
Infant feeding practices					
Exclusively breast milk@					
Breast milk and other food	0.989	1.153***	1.106*	1.116**	1.085
Quality of water					
Improved@					
Not-improved	0.888	0.980	1.094	1.066	0.853
Quality of cooking fuel					
Improved@					
Not-improved	1.318	1.007	0.820	0.820	1.036
Toilet Facilities					
Improved@					
Not-improved	0.933	1.039	1.185**	1.161	1.081
Had Diarrhoea					
No@					
Yes	1.151	1.194**	1.165**	1.173**	1.353**
Had Fever					
No@					
Yes	1.076	1.205**	1.194**	1.241***	1.337**
Had ARI					
No@					
Yes	1.158	0.897	0.863	0.823	0.973
-2 log likelihood	3766.178	4408.200	4537.357	4651.117	1831.733
R^2 Nagelkarke	0.33	0.017	0.048	0.059	0.064
No. of children	3790				

Source: Computed from NFHS-3 data files.

Note: @: reference category. *: 10% significant level, **: 5% significant level, ***: 1% significant level.

Table 6 : Logistic Regression results of socio-demographic and environmental factors on under nutrition among children 6-11 months

Background characteristics	Types of under nutrition				
	Height for age	Weight for age	Weight for height	BMI for age	Height and BMI for age
	Exp (B)	Exp (B)	Exp (B)	Exp (B)	Exp (B)
Region					
South@					
North	0.876	0.934	0.942	0.965	0.719
Central	0.996	1.196*	1.141	1.112	0.970
East	0.964	1.192*	1.137	1.244**	1.573***
North-east	0.887	0.707	0.752	0.685	0.892
West	1.419***	1.264	0.972	0.950	1.454
Place of residence					
Urban @					
Rural	0.969	0.963	0.942	0.966	0.999
Wealth Index					
Richest @					
Poor	1.374***	1.860***	1.522***	1.145***	1.442
Poorer	1.128	1.594***	1.422***	1.416***	1.776***
Middle	1.031	1.115	1.081	1.068	1.125
Richer	0.907	0.765***	0.889	0.918	1.151
Education of mother					
Secondary and above @					
Illiterate	0.951	0.962	0.861	0.877	1.098
Primary	0818	0.879	1.075	0.995	0.486
Age of mother (in years)					
20-24@					
15-19	1.634***	1.241	1.004	0.972	1.357
25-29	0.835*	0.888	1.069	1.044	0.892
30-35	0.873	1.120	1.009	1.018	1.025
35 and above	0.919	0.907	0.930	0.977	1.062
Birth order of the child					
2-3 @					
1st	0.799**	0.781***	0.895	0.943	0.921
4 and above	1.187	1.224**	1.148	1.088	1.083
Infant feeding practices					
Breast milk and other food @					
Exclusively breast milk	0.905	0.915	0.912	0.922	1.810**
Quality of water					
Improved@					
Not-improved	0.997	0.994	0.967	0.972	0.938
Quality of cooking fuel					
Improved@					
Not-improved	1.003	0.897	0.930	0.939	0.931
Toilet Facilities					
Improved@					
Not-improved	1.286***	1.196**	1.050	1.050	0.1604***
Had Diarrhoea					
No@					
Yes	0.930	1.004	1.109	1.110	0.933
Had Fever					
No@					
Yes	1.032	1.034	1.013	1.011	1.017
Had ARI					
No@					
Yes	0.898	0.933	0.956	0.938	0.959
-2 log likelihood	5226.646	5501.661	5373.809	5540.920	2457.720
R^2 Nagelkarke	0.085	0.145	0.059	0.059	0.130
Total no. of children			4606		

Source: Computed from NFHS-3 data files.
Note: @: reference category. *: 10% significant level, **: 5% significant level, ***: 1% significant level.

Table 7: Logistic Regression results of socio-demographic, nutritional and environmental factors on morbidity among children 12-59 months

Background characteristics	Types of morbidity					
	Diarrhoea		Fever		ARI	
	Exp (B)	No. of children	Exp (B)	No. of children	Exp (B)	No. of children
Region						
South@		4699		4699		4699
North	1.008	6093	0.892**	6093	1.215**	6093
Central	0.970	7451	1.100**	7451	1.131*	7451
East	1.128**	5592	1.426***	5592	1.520***	5592
North-east	1.109	6290	0.986	6290	1.228	6290
West	1.120	3637	0.871**	3637	0.878	3637
Place of residence						
Urban @		12615		12615		12615
Rural	0.895	21147	1.038	21147	0.984	21147
Wealth Index						
Richest @		7114		7114		7114
Poor	0.944	5926	0.911*	5926	0.921	5926
Poorer	0.956	6130	1.015	6130	1.177**	6130
Middle	1.000	7062	0.998	7062	1.176**	7062
Richer	1.036	7530	0.997	7530	0.911	7530
Education of mother						
Secondary and above @		1730		1730		1730
Illiterate	1.057	13628	1.118**	13628	1.046	13628
Primary	0.990	18404	0.899	18404	1.006	18404
Age of mother						
20-24@		10261		10261		10261
15-19	1.403***	1109	1.001	1109	1.082	1109
25-29	0.959	12208	1.012	12208	0.993	12208
30-35	0.956	6627	0.981	6627	0.906	6627
35 and above	0.730***	3557	1.031	3557	0.979	3557
Birth order						
2-3 @		15202		15202		15202
1st	0.867***	10620	0.971	10620	0.962	10620
4 and above	1.261***	7940	1.018	7940	1.033	7940
Age of the child (in months)						
12-23@		8296		8296		8296
24-35	1.236**	8420	1.178***	8420	1.090	8420
36-47	0.716***	8598	0.879***	8598	0.912	8598
48-59	0.564***	8448	0.702***	8448	0.755***	8448
Quality of water						
Improved@		26434		26434		26434
Not-improved	0.986	7328	0.948*	7328	0.962	7328
Quality of cooking fuel						
Improved@		8526		8526		8526
Not-improved	1.058	25236	1.056	25236	1.141*	25236
Toilet Facilities						
Improved@		15490		15490		15490
Not-improved	1.079	18272	0.955	18272	0.923	18272
Crowing in household						
Below 3 person@	NA	NA	NA	NA		2559
3-6 person	NA	NA	NA	NA	0.988	17131
6 and above	NA	NA	NA	NA	0.861***	14272
Nutritional status						
Normal height for age@		32082		32082		32082
Stunted	1.022	1680	0.918***	1680	0.909**	1680
Normal weight for age@		20394		20394		20394
Under weight	1.055	13368	1.104***	13368	1.085*	13368
Normal weight for height@		228214		228214		228214
wasted	1.115*	5548	1.092*	5548	1.011	5548
Normal BMI@		29376		29376		29376
Low BMI	0.945	4386	0.923	4386	0.892	4386
Normal height and BMI@		32082		32082		32082
Stunted and low BMI	0.995	1680	1.045	1680	1.064	1680
-2 log likelihood	**19602.598**		**30491.728**		**15674..581**	
R^2 Nagelkarke	**0.055**		**0.028**		**0.031**	
Total No. of children	**36978**		**36978**		**36978**	

Computed from NFHS-3 @: reference category *: 10% significant level,**: 5% significant level,***: 1% significant level

Table 8: Logistic Regression results of socio-demographic and environmental factors on under nutrition among children 12-59 months

Background characteristics	**Types of under nutrition**				
	Height for age	Weight for age	Weight for height	BMI for age	Height and BMI for age
	Exp (B)	Exp (B)	Exp (B)	Exp (B)	Exp (B)
Region					
South@					
North	0.939	0.950	1.021	1.002	1.047
Central	1.236***	1.104***	0.940	0.940	1.071
East	0.943*	1.167***	1.260***	1.202***	1.233***
North-east	0.911	0.762***	0.780***	0.835	0.829
West	1.336***	1.291***	1.082	0.998	1.173
Place of residence					
Urban @					
Rural	0.944***	0.964	0.933**	0.931**	0.931
Wealth Index					
Richest @					
Poor	1.603***	1.744***	1.330***	1.296***	1.612***
Poorer	1.338***	1.342***	1.171***	1.104**	1.329***
Middle	1.135***	1.093***	1.017	0.999	1.084
Richer	0.894***	0.866***	0.885***	0.895**	0.871
Education of mother					
Secondary and above @					
Illiterate	1.024	1.024	1.067	1.058	1.178
Primary	0.706***	0.726***	0.777***	0.805**	0.578***
Age of mother					
20-24@					
15-19	1.470***	1.153**	0.89	0.873	1.022
25-29	0.907***	0.957	0.983	0.975	0.917
30-35	0.799***	0.930*	1.077	1.125**	1.003
35 and above	0.851***	0.943	1.090	1.104	1.053
Birth order					
2-3 @					
1^{st}	0.786***	0.866***	0.988	0.994	0.897
4 and above	1.214***	1.152***	0.991	0.992	1.098
Age of the child (in months)					
12-23@					
24-35	1.118***	1.009	0.957	0.959	1.075
36-47	1.048	1.048	0.866***	0.871***	0.828***
48-59	0.911***	1.027	0.869***	0.860***	0.737***
Quality of water					
Improved@					
Not-improved	0.928***	0.995	1.056**	1.065**	1.039
Quality of cooking fuel					
Improved@					
Not-improved	0.988	1.009	1.009	0.987	0.891
Toilet Facilities					
Improved @					
Not-improved	1.045*	1.012	1.060*	1.042	1.121**
Had Diarrhoea					
No@					
Yes	1.059	1.077***	1.079**	1.048	1.068
Had Fever					
No@					
Yes	0.976	1.074***	1.104***	1.086***	1.067
Had ARI					
No@					
Yes	0.967	0.973	0.924	0.918	0.929
-2 log likelihood	**47740.975**	**47878.043**	**33858.647**	**28880.928**	**15488.896**
R^2 Nagelkarke	**0.115**	**0.105**	**0.035**	**0.024**	**0.052**

Computed from NFHS-3 .Note: @: reference category. *: 5% significant level, **: 1% significant level.