Introduction

Information on child growth is helpful in monitoring trends, determining priorities, evaluating the effectiveness of nutrition intervention programs, and planning or strengthening the existing ones. India is passing through a demographic, socioeconomic, and nutritional transition due to globalization, increased food production, market, liberalization, foreign direct investment, and also the increased income of its population.¹

ABSTRACT

Background: In spite of several national nutrition intervention programs that have been in operation since the past four decades, undernutrition continues to be an important public health problem in India. Aim: The aim of the present study was to assess the trends in food and nutrient intakes and nutritional status of children in India below 5 years of age. Setting and Design: A community-based, cross-sectional study was carried out in ten National Nutrition Monitoring Bureau states by adopting a multistage random sampling procedure. Methods: Data were collected on the household (HH) socioeconomic and demographic particulars, and anthropometric measurements of the children, such as their length/height and weight, were noted. A 24-h dietary recall method was used for assessing dietary intake. Results: Intake of all the foodstuffs except pulses, vegetables, and fats and oils declined over a period of time (1975–1979 to 2011–2012) while the intake of all the micronutrients except Vitamins A and C declined during the same period. The prevalence of undernutrition, i.e. underweight, stunting, and wasting has declined from 76%, 82%, and 27%, respectively in 1975–1979 to 42%, 44%, and 19%, respectively, in 2011–2012 among 1-5 year children. The severe form of undernutrition has also declined during the same period. The prevalence of undernutrition was significantly ($P < 0.01$) higher among children of illiterate mothers, those belonging to lower socioeconomic status, and those living in nuclear families. Conclusions: The prevalence of undernutrition declined over the period despite the decrease in food and nutrient intake. However, the pace of decline was slower and it was attributed to improved health-care services coupled with control of communicable diseases and increase in the HHS income. Further efforts are needed to improve the literacy of parents, environmental and personal hygiene, along with the food security of HHS through a public distribution system.

**KEY WORDS:** Less than 5-year-old children, nutrients, trends, undernutrition
Despite the fact that several nutrition intervention programs have been in operation since the past four decades in India,[3] undernutrition is still high compared to neighboring countries such as Bangladesh and Sri Lanka and continues to be an important public health problem. A large proportion of the world’s undernourished children live in India. Thus, alleviating the burden of undernutrition alone will markedly influence the global prevalence.[3]

Undernutrition among children appears to be associated with high family food insecurity, low quality of complementary foods, and high burden of intestinal, parasitic, and other infections, and has persisted despite the improvement in economic conditions in recent years.[3] The burden of undernutrition appears to be high among the rural and indigenous populations.[4]

Undernutrition directly affects child survival and overall development. It especially retards physical and cognitive growth, undermines educational attainment, and ultimately impacts productivity at work and at home with adverse implication on income and economic growth.[1] About half of under-5 mortality is directly or indirectly associated with undernutrition.[6]

It is estimated that stunting, severe wasting, and intrauterine growth retardation together are responsible for 2.2 million deaths and 21% of disability-adjusted life years in case of children younger than 5 years.[7]

The National Nutrition Monitoring Bureau (NNMB) has been in operation in the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Odisha, West Bengal, and Uttar Pradesh since 1972. Since its inception, the NNMB has been carrying out diet and nutrition surveys on a regular basis in the rural and tribal areas. Baseline survey was carried out among the rural population during 1975–1979; the first and second repeat surveys were conducted during 1988–1990[8] and 1996–1997,[9] respectively, and the third repeat survey was carried out in 2011–2012 among the rural population that was used to assess the trends in nutritional status and nutrient intake among children. This paper presents the results of the above surveys.

Methods

Ethics
The Ethics Committee of National Institute of Nutrition (NIN) approved the study.

The study protocol was approved by the NNMB Steering Committee as well as the Scientific Advisory Committee of the NIN. Ethical clearance was obtained from the Institutional Ethical Review Committee, NIN, Indian Council of Medical Research (ICMR), Hyderabad, Telangana, India. Written informed consent was also obtained from all the mothers of the children involved in the study.

Study design
These community-based, cross-sectional surveys were carried out in ten NNMB states in India, namely, Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Odisha, West Bengal, and Uttar Pradesh by adopting a multistage random sampling procedure.

Sample size
As per the 2001 Census of India, the population of <5-year-old children was about 10%. To assess the nutritional status of children, the sample size required was about 800 children per state.

Selection of villages
To get the required sample of 800 children, 120 villages and 20 households (HHs) from each village, i.e., 120 × 20 = 2400 HHs were covered. Assuming a family size of 4.5, and considering the population of <5-year-old children as 10%, we have covered the required sample from each state. Of these 120 villages, 90 villages were selected that were covered in baseline (1975–1979) and the first (1988–1990) and second repeat surveys (1996–1997); while the remaining 30 new villages (excluding the ones already covered) were randomly selected afresh from the list of villages obtained from the Census of India[10] by adopting a multistage random sampling procedure.

Selection of households
Considering the minimum population of villages to be at least 100 and family size to be 4.5, the total HHs available in any village will be at least 20. Hence, it was suggested that 20 HHs should be covered in each village. For this purpose, the main village and its hamlets, if any, were divided into five geographical areas based on the streets/mohallas/areas. It was ensured that at least one of the five areas was inhabited by the Scheduled Caste (SC)/Scheduled Tribe (ST) communities. From each area, four contiguous HHs were covered by randomly selecting the first HH from the northeast side of the villages. Thus, a total of 20 HHs were covered in each village and 2400 HHs in each state.

Definitions
“HH” is defined as a setting in which those living together under one roof share a common kitchen.

A “pucca” house means one that has walls made up of cement and bricks or stones and reinforced cement concrete roof while a “semi-pucca” house is one that has brick or stone walls and tiled or asbestos roof, and a “kutcha” house has mud or thatched walls and thatched or tiled/asbestos roof.

Data collection
The data were collected by a team comprising one Medical Officer, one nutritionist, and one social worker in each state. All were trained in standardized survey methodologies at NIN for 3 weeks. All the survey instruments were developed and pretested before being used in the field. Information on HH socioeconomic and demographic particulars such as community, religion, education, occupation, and income was collected from all the selected HHs using a precoded and pretested questionnaire. Anthropometric measurements of the children such as their length/height (up to the nearest 1 mm) were measured using an infantometer/anthropometer rod and
weight (up to nearest 100 g) using the SECA (Deutschland, Medical Scales and Measuring system, Hammer Steindamm 9-25, Hamburg, 22089, Germany by adopting standard procedures). History of morbidity such as fever, respiratory infection, and diarrhea, if any, during the preceding 15 days of visit was also noted.

Food and nutrient intakes of individuals
A 24-h dietary recall method was used for assessing dietary intake. The average daily intake of different foods by individuals was calculated according to their age/sex, physiological status, and activity status. The nutrient composition of the foods consumed by the individuals was computed using the food composition tables in the Nutritive Value of Indian Foods. The mean intake of foods and median intake of various nutrients were compared with the suggested balanced diets provided in Recommended Dietary Intake (RDI) for Indians and Recommended Dietary Allowance (RDA) suggested by the ICMR Expert Committee.

Data analysis
The data were cleaned and entered in computers at NIN, Hyderabad, Telangana, India. Data cleaning was done by carrying out the range and consistency checks. Descriptive and analytical statistics of the data were carried out using SPSS (Window version 17.0, SPSS Inc., Chicago, IL, USA). The mean (standard deviation [SD]) intakes for food and median intake for nutrient with interquartile range, test of proportion with crude odds ratio (OR) was done, and multivariate logistic regression analysis was carried out to know the important factors associated with undernutrition as dependant variable and socioeconomic and demographic factors and morbidity as independent variables after adjusting with community.

The nutritional status of children was assessed according to SD classification using the World Health Organization Child Growth Standards. The children who were below 2 SDs of the reference median, i.e., <median-2SD on the basis of “weight-for-age,” “height-for-age,” and “weight-for-height” indices were classified as underweight, stunting, and wasting, respectively, while those who were below 3SD values of the reference median, i.e., <median-3SD were classified as “severe underweight,” “severe stunting,” and “severe wasting,” respectively.

HH wealth was assessed by using principal component analysis (factor analysis). HH socioeconomic and demographic variables such as occupation of the parents, per capita income, land holdings, type of house, source of drinking water, electricity, type of cooking fuel, and sanitary latrine were included in the factor analyses that are proxy for wealth assessment. The first two components explained about 52% of the variance and weighed the heaviest (>0.4). The regression scores from the first component were used to create an index that was divided into tertiles.

**Results**

Trends in nutrient intakes and nutritional status are available for seven states except Uttar Pradesh, Odisha, and West Bengal. The intake of all nutrients seemed to have declined except Vitamins A and C, thiamin, riboflavin, and niacin, among children aged 4–6 years. Although the intake of protein declined over the period of time, it was above the RDA. Iron intake had significantly declined over the period of four decades and was 64%–66% of RDA [Figures 1 and 2].

**Trends in nutritional status among 1–5-year-old children (seven states)**
The prevalence of undernutrition among 1–5-year-old children had significantly declined over the years. The prevalence of underweight had declined from 76% during 1975–1979 to 42% during 2011–2012 while the prevalence of stunting had declined from 82% to 44% during the same period. The prevalence of wasting declined from 27% to 19% during the above said period [Figure 3].

**Coverage particulars**
A total of 9038 children aged 0–59 months (boys: 50.9%) with a mean age of 28.6 ± 16.2 months were covered in the present survey while 5698 preschoolchildren were covered in 1975–1979 and 8656 in 1996–1997.

**Socioeconomic and demographic profiles of the study children in the present survey**
About 42% of the HHs covered belonged to SC/ST communities, while 35% belonged to other backward communities. More than half (57.2%) of the HHs were living in semi-pucca houses, while 22% were living in kutcha houses. About 45% of HHs were nuclear families while 36% were joint families. About 31% of fathers and 48% of mothers of the index children were illiterate. About 41% of the HHs did not possess agricultural land and 47% were engaged in labor. About half (50.4%) of the mothers were homemakers. About 43% of the HHs had per capita income below Rs 600/month. Only 36% of the HHs had access to tap water and the majority (88%) were using firewood for cooking purposes. Only 29% of the HHs were using sanitary latrine and 76% had electricity.

**Food and nutrient intake among children in the present survey**
Mean intake of all the foodstuffs, except roots and tubers, was below the RDI. The intakes of green leafy vegetables,
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milk and milk products, fats and oils, and sugar and jaggery were <50% of the RDI. Similarly, the intake of all nutrients, except proteins and thiamin, was below the RDA [Tables 1 and 2].

prevalence of undernutrition

state-wise prevalence of undernutrition

The prevalence of undernutrition was higher among the children in Madhya Pradesh (underweight: 54.2%, stunting: 51.3%, and wasting: 32%) followed by Gujarat (underweight: 52.4%, stunting: 53.8%, and wasting: 28.1%), and Uttar Pradesh (underweight:

![Figure 2: Trends in nutrient intakes among 3–6-year-old children (% of recommended dietary allowance)](image)

![Figure 3: Trends in nutritional status of 1–5-year-old children (7 states’ data)](image)

Table 1: Mean intake of foodstuffs (g) and percentage of recommended dietary intake among 1-6-year-old children

| Foods                | Cereals and millets | Pulses and legumes | Green leafy vegetables | Other vegetables | Roots and tubers | Milk and milk products | Fats and oils | Sugar and jaggery |
|----------------------|---------------------|--------------------|------------------------|------------------|-------------------|------------------------|---------------|-------------------|
| 1-3 years            |                     |                    |                        |                  |                   |                        |               |                   |
| Mean                 | 131                 | 15                 | 7                      | 13               | 21                | 86                     | 6             | 10                |
| SD                   | 82                  | 18                 | 20                     | 26               | 33                | 144                    | 7             | 14                |
| RDI                  | 175                 | 35                 | 40                     | 20               | 10                | 300                    | 25            | 30                |
| % RDI                | 74.8                | 42.8               | 17.5                   | 65               | 210               | 28.7                   | 24            | 33.3              |
| 4-6 years            |                     |                    |                        |                  |                   |                        |               |                   |
| Mean                 | 209                 | 20                 | 10                     | 23               | 37                | 67                     | 9             | 10                |
| SD                   | 97                  | 22                 | 27                     | 37               | 47                | 108                    | 8             | 13                |
| RDI                  | 270                 | 35                 | 50                     | 30               | 20                | 250                    | 25            | 40                |
| % RDI                | 77.4                | 57.1               | 20                     | 76.7             | 185               | 26.8                   | 36            | 25                |

SD: Standard deviation, RDI: Recommended dietary intake

Table 2: Median (interquartile range) intake of nutrients and percentage of recommended dietary allowance among 1-6-year-old children

| Nutrients               | 1-3 years | RDA (% RDA) | 3-6 years | RDA (% RDA) |
|-------------------------|-----------|-------------|-----------|-------------|
| Protein (g)             | 19.7 (12.8-27.8) | 16.7 (118) | 27.9 (20.1-37.5) | 20.1 (339) |
| Fat (g)                 | 11.8 (6.7-20) | 27 (43.7) | 15.0 (9.3-23.1) | 25 (60)     |
| Energy (kcal)           | 733 (494-995) | 1060 (69) | 1033 (790-1298) | 1350 (76.5) |
| Calcium (mg)            | 166.4 (85.5-308.7) | 600 (27.7) | 198.3 (116.6-326.3) | 600 (33) |
| Vitamin A (µg)          | 61.3 (26.1-144.3) | 400 (15.2) | 74.0 (36.6-158.5) | 400 (18.5) |
| Thiamin (mg)            | 0.5 (0.3-0.7) | 0.5 (100) | 0.7 (0.5-1.0) | 0.7 (100) |
| Riboflavin (mg)         | 0.3 (0.2-0.5) | 0.6 (50) | 0.4 (0.3-0.6) | 0.8 (50) |
| Niacin (mg)             | 4.8 (2.9-7.2) | 8 (60) | 7.6 (5.4-10.5) | 11 (69) |
| Vitamin C (mg)          | 8.6 (3.0-19.0) | 40 (22.5) | 15.3 (6.6-29.4) | 40 (37.5) |
| Iron (mg)               | 4.7 (2.6-7.7) | 9 (52.2) | 7.2 (4.6-11.4) | 13 (55) |
| Free folate (µg)        | 19.4 (11.7-29.3) | 80 (24.3) | 28.1 (18.6-40.1) | 100 (28) |

IQ: Interquartile, RDA: Recommended dietary allowance
50.7%, stunting: 52.2%, and wasting 25.6%) and was the lowest in Kerala (underweight: 22.6%, stunting: 22.7%, and wasting: 16.5%) [Table 3].

Prevalence of undernutrition by age group and gender
In general, the prevalence of underweight among under-5 children was about 42% and this was similar among boys (42.1%) and girls (41.4%); the prevalence of stunting was 43% and was higher among boys (44.3%) compared to girls (41.9%), and the prevalence of wasting was 22%, which was similar among both the genders (boys: 22.5%, girls: 21.5%) [Table 4].

Association of undernutrition with socioeconomic and demographic factors
Background characteristics were analyzed to know the factors associated with undernutrition. It was observed that the prevalence of undernutrition was significantly higher among children from SC and ST communities, children belonging to nuclear families, children of illiterate parents, those from low per capita income families, those living in kutch houses, those whose parents were engaged in labor, and those who did not have access to sanitary latrine [Table 4].

Adjusted logistic regression analysis was carried out to know the important risk factors associated with undernutrition as dependant variable and socioeconomic and demographic factors, morbidity as independent variables after adjusting with community. It was observed that the risk of underweight and stunting was 2–3 times higher among older children (OR for underweight 2.42; confidence interval [CI] = 2.11–2.76; and OR for stunting 2.70; CI = 2.34–3.10) as compared to 0–11 months children. The risk of underweight and stunting was 1.5 times higher among children living in nuclear families (OR for underweight 1.50; CI = 1.32–1.71; OR for stunting 1.43; CI = 1.25–1.63) compared to children from joint families.

The risk of underweight and stunting was 1.8 times higher among children of illiterate mothers (OR for underweight 1.65; CI = 1.44–1.88; OR for stunting 1.77; CI = 1.53–2.05) and stunting (OR 1.72; CI = 1.51–1.95) as compared to children from highest economic status. The risk of wasting was 1.2 times higher among children from nuclear families (OR 1.18; CI = 1.04–1.34), 1.3 times higher among children of illiterate mothers (OR 1.29; CI = 1.10–1.50), and 1.4 times higher among children from lower socioeconomic group (OR 1.35; CI = 1.16–1.57). The risk of wasting was higher among children with a history of morbidity during previous fortnight (OR 1.24; CI = 1.06–1.45) as compared to children without any morbidity [Table 5].

Discussion
Child undernutrition remains one of the important public health challenges of the 21st century. Recent global estimates suggest that stunting, wasting, and intrauterine growth retardation are responsible for 2.2 million deaths and 21% of disability-adjusted life-years lost among children under 5 years of age.[7]

The study reported that the median intake of nutrients was below the recommended levels except for thiamine and proteins and was grossly deficient in Vitamin C, riboflavin, and folic acid.

The present study reported that the prevalence of underweight, stunting, and wasting was 42%, 43%, and 22%, respectively; the prevalence was higher in the states of Madhya Pradesh, Uttar Pradesh, and Gujarat and lowest in Kerala. The prevalence of undernutrition was similar in both the genders.

It was observed that the prevalence of undernutrition had declined over the period in spite of the decline in food and nutrient intake. The study carried out by the National Sample Survey Organisation during 2005 also observed that there was a decline in food and nutrient intake.[8] This decline in food and nutrient intake may be due to the decrease in energy expenditure, along with limited activities. The prevalence of underweight, stunting, and wasting has declined from 76%,

Table 3: State-wise prevalence of undernutrition (< median-2 standard deviation) among <5-year-old children (current survey)

| States            | n   | Underweight | Stunting | Wasting |
|-------------------|-----|-------------|----------|---------|
| Andhra Pradesh    | 1003| 36.6 (33.6–39.6) | 44.7 (41.6–47.8) | 15.0 (12.8–17.2) |
| Gujarat           | 1043| 52.4 (49.4–55.4) | 53.8 (50.8–56.8) | 28.1 (25.4–30.8) |
| Karnataka         | 860 | 41.2 (37.9–44.5) | 39.3 (36.0–42.6) | 21.9 (19.1–24.7) |
| Kerala            | 647 | 22.6 (19.4–25.8) | 22.7 (19.5–25.9) | 16.5 (13.6–19.4) |
| Maharashtra       | 914 | 34.6 (31.5–37.7) | 44.1 (40.9–47.3) | 14.3 (12.0–16.6) |
| Madhya Pradesh    | 949 | 54.2 (51.0–57.4) | 51.3 (48.1–54.5) | 32.0 (29.0–35.0) |
| Odisha            | 967 | 44.6 (41.5–47.7) | 48.5 (45.3–51.7) | 17.6 (15.2–20.0) |
| Tamil Nadu        | 754 | 31.2 (27.9–34.5) | 21.0 (18.1–23.9) | 27.2 (24.0–30.4) |
| Uttar Pradesh     | 1094| 50.7 (47.7–53.7) | 52.2 (49.2–55.2) | 25.6 (23.0–28.2) |
| West Bengal       | 807 | 38.7 (35.3–42.1) | 40.2 (36.8–43.6) | 21.1 (18.3–23.9) |
| Pooled            | 9038| 41.8 (40.8–42.8) | 43.1 (42.1–44.1) | 22.0 (21.1–22.9) |

Figures in parentheses are 95% CI. CI: Confidence interval, SD: Standard deviation
Table 4: Prevalence (%) of undernutrition among different age and sociodemographic groups

| Sociodemographic particulars | n     | Underweight | Stunting | Wasting |
|------------------------------|-------|-------------|----------|---------|
| Age groups (months)          |       |             |          |         |
| 0-11                         | 1668  | 26.5        | 23.4     | 25.4    |
| 12-35                        | 3759  | 42.7        | 49.4     | 20.9    |
| 36-59                        | 3611  | 47.9        | 45.8     | 21.7    |
| Pooled                       | 9038  | 41.8        | 43.1     | 22.0    |
| \(\chi^2, P\)                | 217.2, 0.000 | 325.9, 0.000 | 131.2, 0.001 |
| Gender                       |       |             |          |         |
| Boys                         | 4601  | 42.1        | 44.3     | 22.5    |
| Girls                        | 4437  | 41.4        | 41.9     | 21.5    |
| \(\chi^2, P\)                | 0.48, 0.48 | 5.4, 0.01   | 1.2, 0.25 |
| Community                    |       |             |          |         |
| Scheduled tribe              | 1492  | 54.0        | 54.0     | 29.0    |
| Scheduled caste              | 2292  | 44.5        | 46.0     | 25.2    |
| OBC                          | 3133  | 40.0        | 41.6     | 20.0    |
| Others                       | 2121  | 32.4        | 34.6     | 16.9    |
| \(\chi^2, P\)                | 178.8, 0.001 | 140.8, 0.000 | 90.9, 0.000 |
| Type of family               |       |             |          |         |
| Nuclear                      | 4094  | 47.0        | 47.5     | 24.3    |
| Extended nuclear             | 1671  | 40.1        | 41.5     | 21.7    |
| Joint                        | 3273  | 35.9        | 38.4     | 19.4    |
| \(\chi^2, P\)                | 98.7, 0.000 | 61.7, 0.000 | 24.3, 0.000 |
| Family size                  |       |             |          |         |
| 1-4                          | 2479  | 41.1        | 41.4     | 21.8    |
| 5-7                          | 4854  | 42.5        | 44.2     | 22.6    |
| \(\geq 8\)                   | 1705  | 40.9        | 42.5     | 20.7    |
| \(\chi^2, P\)                | 1.93, 0.37 | 5.75, 0.05  | 2.72, 0.25 |
| Education of father          |       |             |          |         |
| Illiterate                   | 2929  | 47.7        | 50.5     | 23.3    |
| 1-8th class                  | 3120  | 42.4        | 41.5     | 23.1    |
| 9th and above                | 2980  | 35.2        | 37.6     | 19.6    |
| \(\chi^2, P\)                | 96.2, 0.000 | 101.6, 0.000 | 14.6, 0.001 |
| Education of mother          |       |             |          |         |
| Illiterate                   | 4452  | 47.9        | 50.2     | 23.7    |
| 1-8th class                  | 2612  | 40.2        | 39.8     | 22.7    |
| 9th and above                | 1955  | 29.8        | 31.4     | 17.5    |
| \(\chi^2, P\)                | 185.9, 0.000 | 208.8, 0.000 | 29.8, 0.001 |
| SES particulars              | n     | Underweight | Stunting | Wasting |
| Occupation of head of HHs    |       |             |          |         |
| Laborer                      | 4275  | 46.1        | 46.1     | 24.2    |
| Cultivators                  | 2376  | 42.6        | 45.1     | 22.5    |
| Artisan                      | 417   | 42.0        | 41.8     | 19.5    |
| Service + business           | 1450  | 31.5        | 35.0     | 17.7    |
| \(\chi^2, P\)                | 94.1, 0.000 | 55.5, 0.000 | 27.4, 0.000 |
| Wealth index (tertile)       |       |             |          |         |
| Lower                        | 2922  | 52.5        | 53.7     | 26.5    |
| Middle                       | 2937  | 43.6        | 44.5     | 22.8    |
| Highest                      | 2979  | 29.8        | 31.9     | 17.3    |
| \(\chi^2, P\)                | 318.3, 0.000 | 279.1, 0.000 | 69.7, 0.000 |
better care and nutrition for the self and the child reduce the probability of morbidities and hence, better the survival and nutritional status of children.\cite{26}

**Conclusions**

The prevalence of undernutrition declined over the period despite the decrease in food and nutrient intake. This may be attributed to the improved access to health-care services coupled with the control of communicable diseases and increased HHs income. There is a need to strengthen the existing nutrition intervention program, along with improvement in the literacy of the parents and personal hygiene, and HHs food security through public distribution system and improving employment opportunities.

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**Conflicts of interest**

There are no conflicts of interest.

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