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RESEARCH ARTICLE

Divergence in time trends between nutrition and health status of Indian children: an enigma?

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ABSTRACT

India has been food secure and children had access to essential health and nutrition services for four decades but under-nutrition rates in children continue to be high. Despite the high prevalence of low birthweight (LBW) and under-nutrition, under-five mortality rates are relatively low: the 'South Asian enigma'.

Data from research studies and large-scale nutrition and health surveys were analysed and reviewed to assess:

- dimensions, determinants and time trends of under-nutrition in under-five children,
- functional decompensations associated with LBW and under-nutrition,
- factors responsible for 'South Asian enigma', and
- progress towards Sustainable Development Goals (SDG) for child nutrition and health.

Neonates born with low weight and length, follow a lower trajectory of growth throughout childhood; this was the major factor responsible for the high under-nutrition rates in children. Breast feeding was nearly universal; about 2/3rd of infants were solely breast-fed at 5 months; but both complementary feeds and adult food given to children were inadequate and lacked diversity. This resulted in a rise in under-nutrition rates between 12-23 months. In 24-59 months there was no further rise in under-nutrition rates. Moderate under-nutrition is not associated with increase in risk of infections; health care for infection was available and utilised; therefore, mortality rates were low.

India will not be able to achieve the SDG targets for reduction in low birthweight or under-nutrition but is likely to achieve the targets for reduction in food insecurity and under-five mortality.

Keywords under-five children, under-nutrition, growth monitoring, India, nutrition and morbidity, nutrition and mortality, nutritional status.

Introduction

Seven decades ago, low birth weight, under-nutrition and high under-five mortality were major public health problems in India. In the 1960s, the majority of people were poor, had inadequate food intake and were chronically under-nourished[1]. The prevalence of infections was high due to poor environmental hygiene and lack of access to safe drinking water[1,2]. Immune depression in under-nourished children increased susceptibility to infections; repeated untreated infections aggravated under-nutrition in children[3-5]. Poor access to health care for the treatment of infections led to aggravation of under-nutrition and high infant and under-five mortality[6]. Multi-sectoral intervention programmes were initiated to improve household food security, provide food supplementation to pre-school children to bridge the gap between energy requirement and dietary energy intake and improve access to primary health care for the prevention and treatment of infections in children[7]. Concurrently, the country invested in clinical, operational and epidemiological research to identify country-specific interventions which would accelerate improvement in child nutrition and health[8]. Data from national surveys provided information on changing nutrition and health scenario, coverage and content of ongoing interventions. Based on all these, appropriate mid-course corrections in the ongoing nutrition and health programmes were made and new initiatives were drawn up and implemented.

A review of the progress achieved till 2022, showed that the country had been self-sufficient in food production for four decades. In the last two decades, India has been one of the fastest-growing economies in the world. The country achieved the Millennium Development Goal (MDG) for poverty reduction by 2012[9]. Since 2013, two-thirds of families are legally entitled to receive subsidized food grains[10]. India has been implementing the world's largest food supplementation programmes for pre-school children for over four decades[7]. Access to nutrition and health care is universal, though there are inadequacies in the content, quality and timeliness of the services[9]. Despite all these interventions, the pace of reduction in under-nutrition has been slow; the prevalence of low birthweight and child under-nutrition in the country continues to be the highest in the world. But infant and under-five mortality had been relatively low[6]: the 'South Asian enigma[11]. India achieved the MDG targets for infant and under-five mortality reduction by 2015[9].

The current manuscript reports the findings from a review of research studies over the last four decades, a review of the reports of, and secondary data analysis from, large-scale nutrition and health surveys on:

- dimensions, determinants and time trends in under-nutrition in pre-school children,
- functional decompensations associated with under-nutrition,
- factors responsible for the 'South Asian enigma', and
- progress towards Sustainable Development Goals (SDG) targets for child nutrition and health.

Material and methods

Low birth weight (LBW), under-five under-nutrition and under-five mortality were major public health problems in the country. Right

from the 1960s efforts were made to undertake research studies to determine the dimensions, determinants and interactions between food security, nutrition and health status in under-five children.

The nutrition and health service reporting systems in the country were sub-optimal in the 1960s and 70s; therefore, national surveys to monitor the coverage, content, problems in the implementation of the national programmes and the impact of interventions on the health and nutritional status of children were planned and undertaken. The major surveys include

- Food production surveys carried out by the Dept of Agriculture[12];
- Consumption expenditure surveys on food and non-food items conducted by the National Sample Survey Organisation (NSSO)[13];
- Diet, nutrition and health surveys carried out by the National Nutrition Monitoring Bureau (NNMB)[14];
- Sample registration surveys on births and deaths carried out by the office of Registrar General of India (RGI)[15];
- National Family Health Surveys (NFHS 1-5)[16] and District Level Household Surveys (DLHS 1-4)[17] carried out by the International Institute of Population Sciences (IIPS);
- Annual Health Survey (AHS) conducted by the office of RGI[18].

The protocol and sampling frame for all the surveys had been prepared carefully by expert groups. Persons administering the surveys were trained before the initiation of the surveys. For the nutrition surveys, equipment for anthropometric measurements was centrally procured and tested for accuracy before being sent to the survey agencies. All the para-professionals recruited by various agencies for undertaking the nutrition component of the survey were trained in taking anthropometric measurements accurately. Data analysis was carried out by experts in the concerned domains and statistics.

The findings from research studies and national surveys were extensively reviewed once in five years by the Planning Commission and concerned ministries of Government of India; based on the findings from these reviews, appropriate modifications were made in ongoing programmes and new intervention programmes were initiated. All these data were reviewed during 2022-23.

Energy requirements for the reference population were taken from the Report on Nutrient Requirements of Indians[19] and the energy requirements for actual weight were computed. This computation was used to assess the food security and adequacy of dietary intake in children.

Data from research studies were reviewed to assess LBW incidence, survival and growth of low-birth-weight infants.

Secondary data analysis pertaining to 205,004 under-five children from the AHS[18] and DLHS4[20] (surveys carried out between 2012 and 2014) was undertaken to compute:

- growth (height, weight and BMI);
- changes in prevalence of stunting, underweight and wasting (by BMI for age and weight for height) in relation to age;

Data on time trends in:

- dietary intake from NNMB surveys and;
- prevalence of under-nutrition from NNMB surveys (1973-2012) and NFHS (2005-2021) were compiled.

The current prevalence of moderate and severe wasting and under-nutrition rates in different socio-economic groups were compiled from NFHS 5 data.

From research studies on nutrition-infection interactions:

- risk of infection in under-nutrition;
- impact of infection on nutritional status; and
- morbidity and mortality in severe acute malnutrition

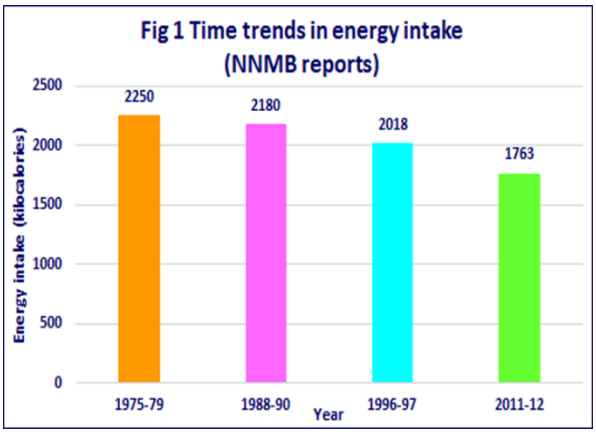
were compiled.

Time trends in neonatal, infant and under-five mortality were compiled from SRS[15].

Results

Time trends in energy intake compiled from NNMB surveys showed that over the last three decades there had been some reduction in the energy intake (Figure 1).

DIETARY INTAKE AND FOOD SECURITY



Estimated average requirements (EAR) computed for age groups using reference body weight from the report on Nutrient Requirements and nutrient requirements for the actual weight in children and adults from the NNMB survey 2012 is given in Table 1.

In a majority of the households dietary intake met the computed EAR for the current average weight of the family members. In under-five children, the gap between EAR for the current weight of children and the estimated average intake was relatively small. The small but sustained higher energy intake in sedentary adult men and women appears to be the major factor responsible for the progressive increase in over-nutrition in adults[9].

Table 1 Energy requirement and intake in Indians
(for reference population and actual weight)

	Age (mth or yr)	Ref wt (kg)	EAR for ref wt	Actual wt (NNMB)	EAR for Actual weight	Energy intake (NNMB)	Gap between EAR and intake
Infant	0-6 mth	5.8	550	4.1	390		
	6-12 mth	8.5	670	6.7	530		
Child	1-3 yr	11.7	1010	10.5	910	733	-177
	4-6 yr	18.3	1360	14.6	1100	1033	-67
	7-9 yr	25.3	1700	19.7	1325	1241	-84
Boys	10-12 yr	34.9	2220	26.6	1700	1403	-290
Girls		36.4	2060	26.7	1510	1330	-180
Boys	13-15 yr	50.5	2860	36.8	2100	1594	-490
Girls		49.6	2400	36.9	1800	1500	-300
Boys	16-18 yr	64.4	3320	45.7	2360	1785	-575
Girls		55.7	2500	42.6	1910	1588	-322
Adult men		65	2100	52	1680	1846	+166
Adult women		55	1660	47	1420	1664	+244

INTRA-FAMILY DIFFERENCES IN DIETARY INTAKE AND NUTRITIONAL STATUS

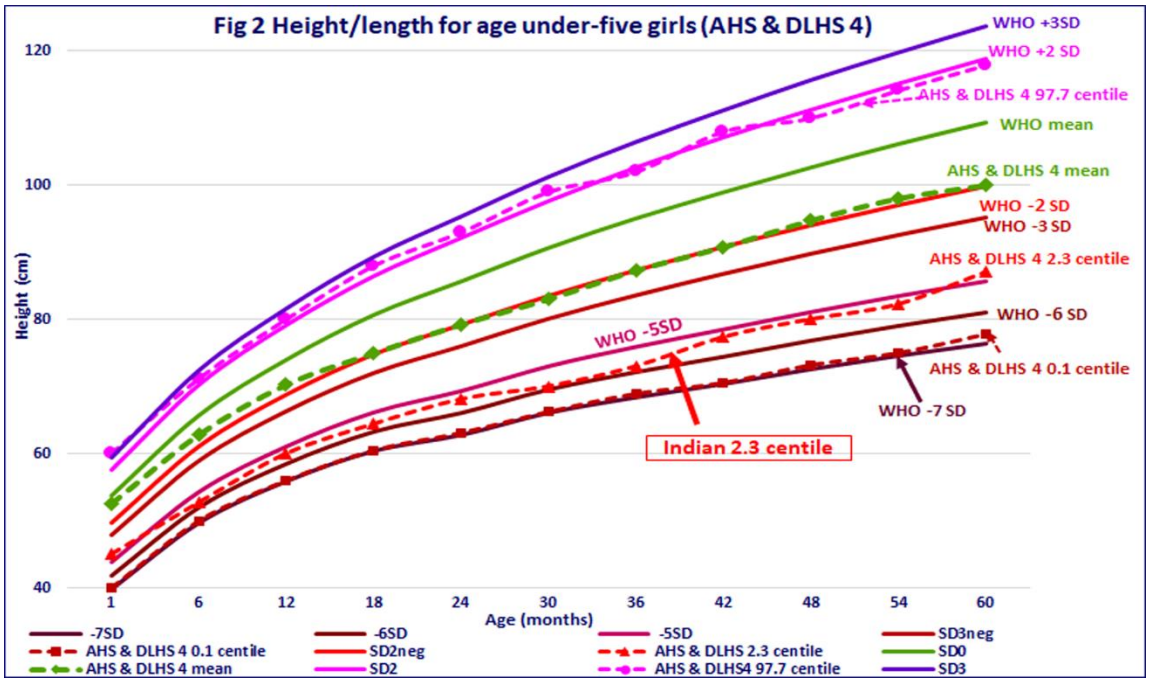
The NNMB surveys in the 1990s had shown that in about a third of the families surveyed, adults had adequate energy intake, but energy intake in under-five children was inadequate. The NFHS 3 was the first national survey to document intra-family differences in the nutritional status between mothers and children; even in families where the mothers were normally nourished or over-nourished, the prevalence of under-nutrition in pre-school children was high[21]. Research studies in urban food-secure families[22-25] showed that in food-secure low-middle-income urban families, there were intra-family differences in nutritional status between:

- mother and under-five child,
- parents, other women and under-five children,
- between two under-five siblings in the same family.

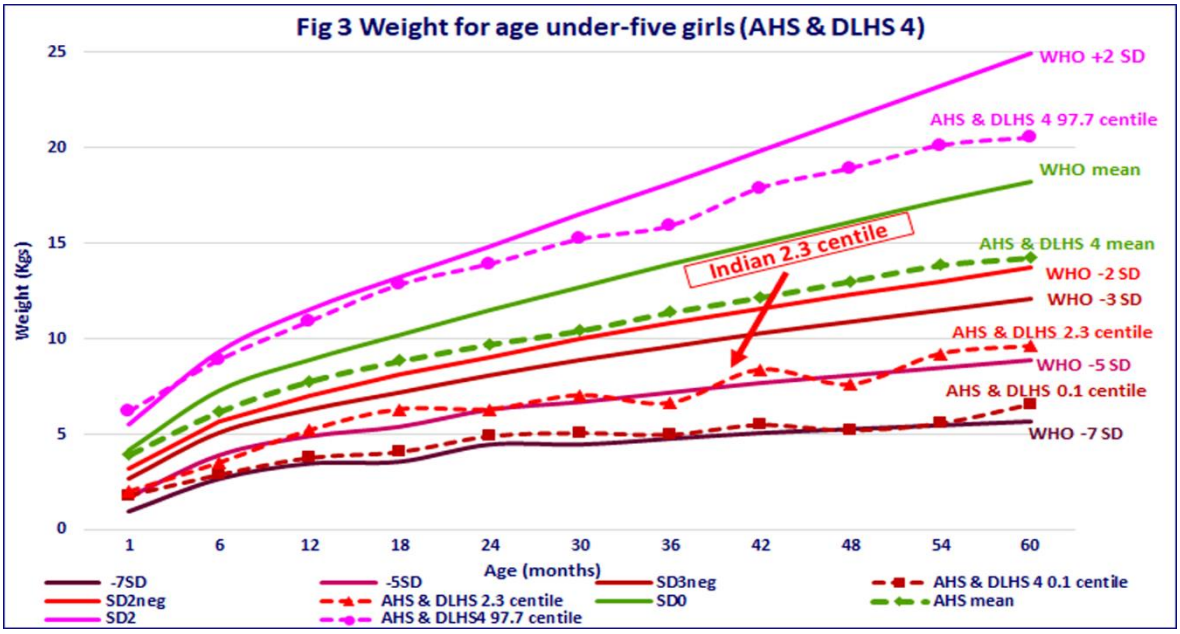
LOW BIRTH WEIGHT

Research studies carried out in Delhi in 1960s showed that small mature Indian neonates survived if given essential newborn care, warmth and breast-feeding. Only neonates who were born prior to 37 weeks, weighed <2 kg at birth or were ill (about 10-15% of all neonates), were at high risk of morbidity and mortality and required intensive care[26,27]. Follow up studies showed that low birth weight neonates had a lower trajectory of growth[27].

GROWTH OF UNDER-FIVE CHILDREN



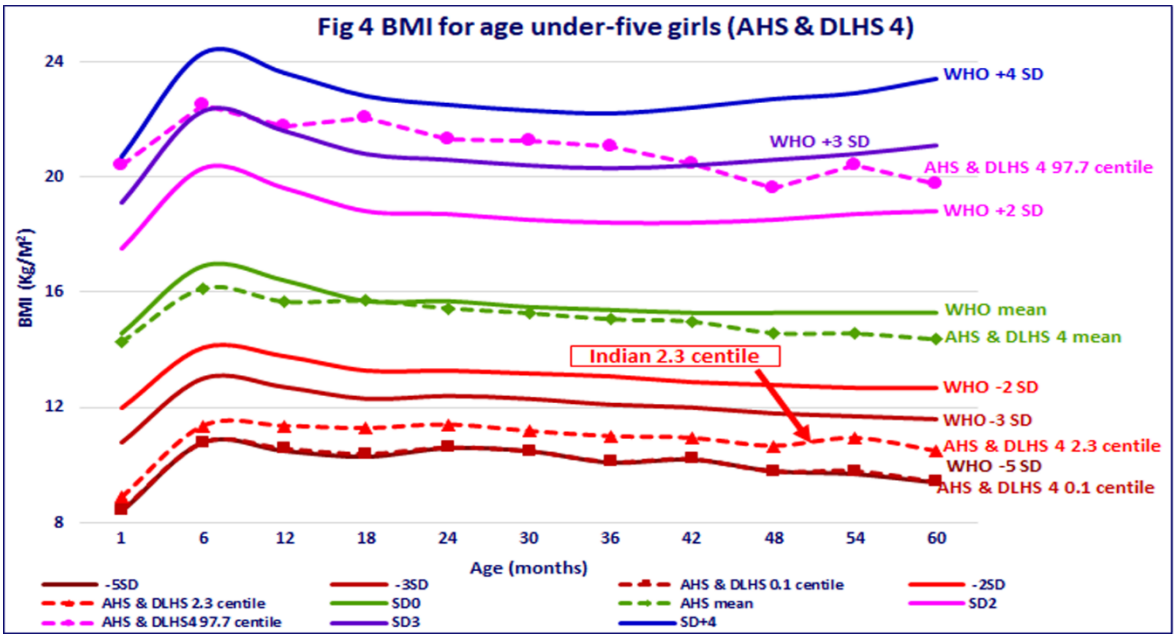
Data from small-scale research studies indicate that the growth of Indian children followed a lower trajectory as compared to the standards of World Health Organisation (WHO) Multi- country Growth Reference Studies (MGRS). Analysis of data on height, weight and BMI for



age in under-five children from NFHS3, AHS and DLHS 4 confirmed that:

➢ the median height and weight for age for Indian children was along the -2 SD trajectory for height and weight of WHO MGRS standards; the 2.3 centile of the height and weight of Indian children were below the -5 SD of the WHO MGRS standards (Figures 2 and 3).

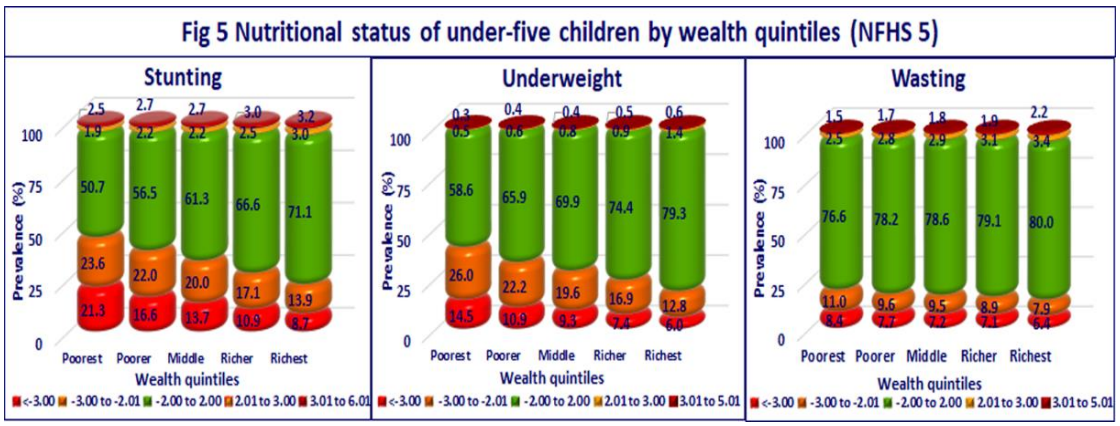
➢ the median BMI for age in Indian children was near the WHO mean BMI for age or a little lower. The 2.3 centile of the BMI for age of Indian children was around -4SD of the WHO values for BMI for age and 0.01 centile of BMI for age of Indian children is on -5 SD of the WHO values (Figure 4).



➢ there were no deviations in the growth trajectory for height, weight or BMI in Indian children with increasing age (Figures 2, 3 and 4).

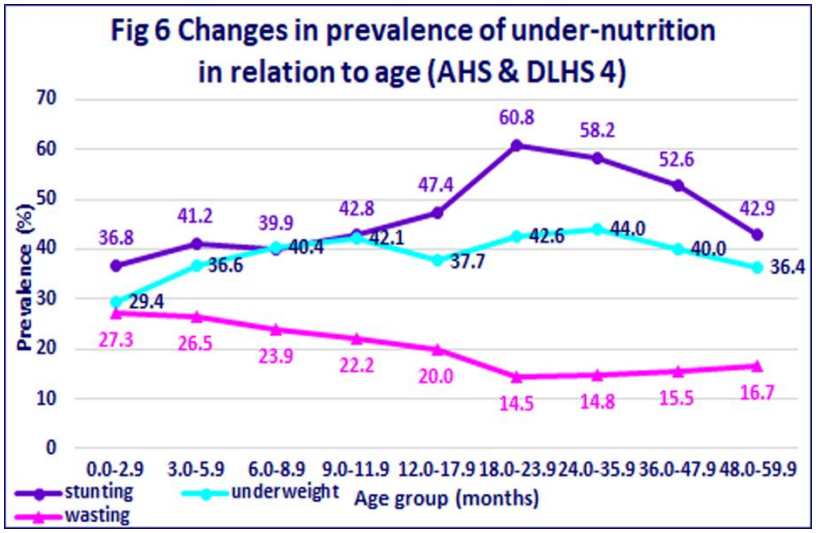
PREVALENCE OF UNDER-NUTRITION OF UNDER-FIVE CHILDREN BY WEALTH QUINTILES

Prevalence of stunting, underweight and wasting in the wealth quintiles reported in the NFHS 5 is shown in Figure 5. There was a gradient in the prevalence of stunting and underweight between wealth quintiles. Prevalence of stunting and underweight in the lowest quintile was nearly double as compared to the highest quintile. The differences in prevalence of wasting in children between the wealth quintiles was much smaller because differences in weight and height for age between wealth quintiles were essentially similar.



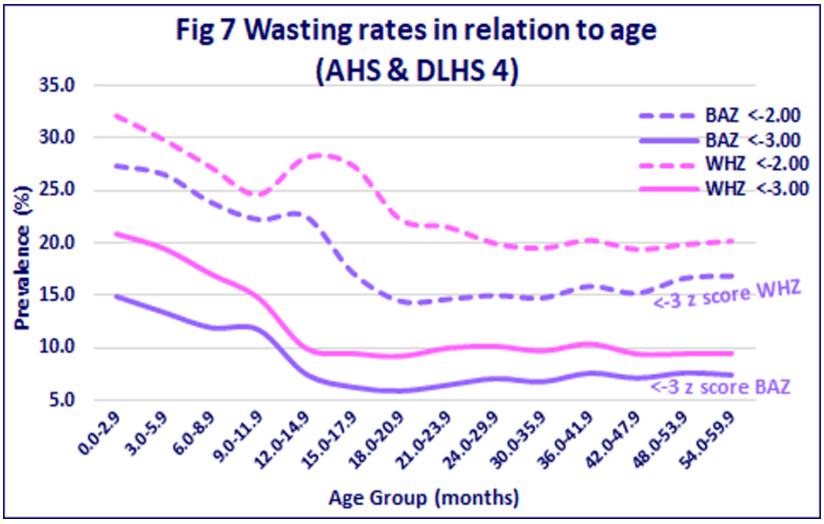
CHANGES IN PREVALENCE OF UNDER-NUTRITION IN RELATION TO AGE

Age-specific changes in prevalence of stunting, underweight and wasting in children (AHS and DLHS 4) is given in Figure 6. Similar trends of changes in under-nutrition rates in relation to the age of the children had been reported in all national surveys[14,16-18,20].



ASSESSMENT OF WASTING IN RELATION TO AGE

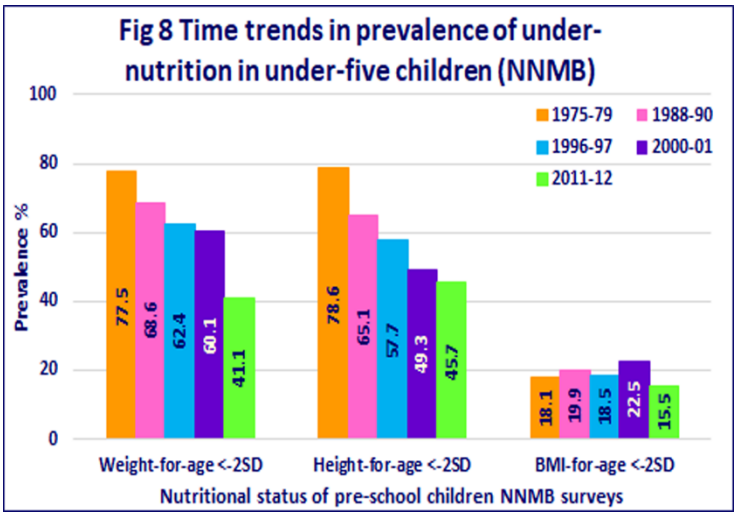
Data from AHS and DLHS 4 were analysed and prevalence of moderate and severe wasting in under-five children were computed using weight for height and BMI for age (Figure 7). At each age group, prevalence of wasting (both moderate and severe) as assessed by weight for height was higher as compared to the wasting rates assessed by BMI for age.



TIME TRENDS IN PREVALENCE OF UNDER-NUTRITION

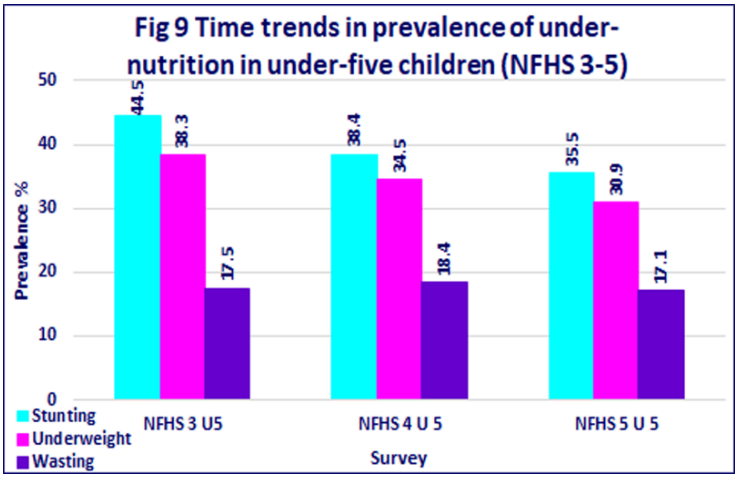
Data from NNMB surveys[14] (Figure 8) and NFHS 3-5[16] (Figure 9) showed that over the last four decades there had been a slow but sustained reduction in stunting and underweight but there was not much change in wasting rates. The estimated average

reduction in stunting rates was about 1%/year. Stunting, underweight and wasting rates were not related to food insecurity either at the national or at the household level[7,28].

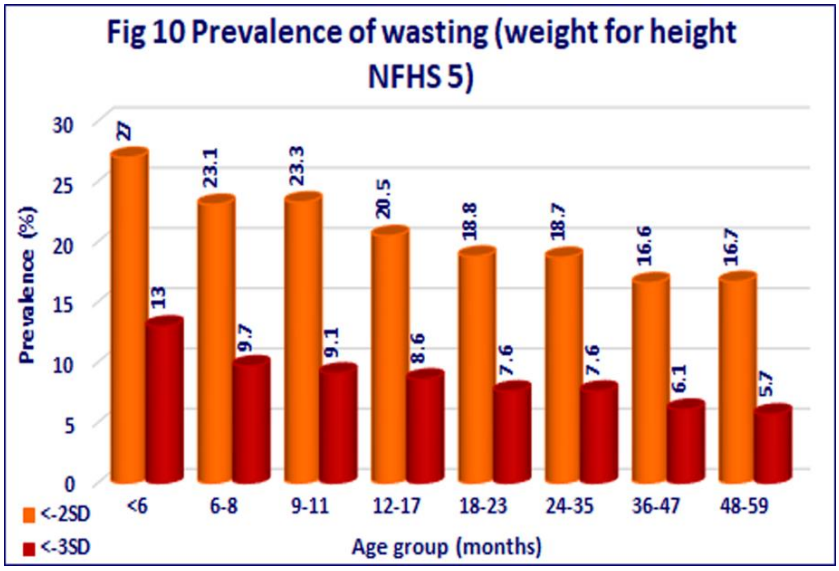


TIME TRENDS IN SEVERE UNDER-NUTRITION

Research studies from India showed that, unlike the situation in Sub-Saharan Africa, kwashiorkor occurred in older children between 2-3 years of age, subsisting on breast milk and inadequate quantities of adult food with low energy and micronutrient density. In these chronically under-nourished children, severe infections, mostly diarrhoea precipitated kwashiorkor. Management of infection with antibiotics saved lives: case fatality rate in India was below 10%[29].



In India prevalence of moderate (WHZ <-2) and severe (WHZ <3) wasting had been and continues to be high[30] (Figure 10). Most of the children with weight for height z scores below -3 were low birthweight neonates who were growing along a low trajectory of height, weight and weight for height. Very few had severe infections or pedal oedema.



MORBIDITY AND MORTALITY RATES IN RELATION TO NUTRITIONAL STATUS OF CHILDREN

Five decades ago, data from India and other developing countries showed that under-nutrition was associated with immune depression and increased susceptibility to infections; repeated and untreated infections aggravated under-nutrition; under-nutrition was the underlying factor in half of the under-five deaths[3,4]. Analysis of data from NFHS 3 showed that prevalence of morbidity due to infection continued to be high in under-five children. There was a small but statistically significant increase in the risk of morbidity due to infections in underweight and wasted children but not in stunted children[31]. A recent community based mixed longitudinal study showed that prevalence of infections in urban low middle income pre-school children was high. Increase in risk of infection in children who were under-nourished as compared to those who were normally nourished prior to infection was small. The deterioration in nutritional status following infection was small because of ready access to and utilization of health and nutrition care[32,33].

Follow up of children admitted in the hospital with severe under-nutrition (weight for height z score <-3) with infections showed that when treated with antibiotics and appropriate high energy and high nutrient food, the children recovered and the mortality rates were less than 2%. Follow-up of severely under-nourished children in the community settings showed that even in the absence of any special care, about a third of them improved and became moderately wasted[34-36.]

About a third of the children in the country are born with low birthweight; India has the highest prevalence of under-nutrition in the world. Despite these, infant and under five mortality rates had been relatively low[15]. This had been called the 'South Asian Enigma'[11]. Over the last four decades there had been a steady decline in the neonatal, infant and under-five mortality rates[37]. India achieved the target for under-five mortality set under the MDG[9].

Discussion

In 1950s and 60s India was not self-sufficient in food grain production. Majority of people

were poor. The small stature and thinness of children and adults was thought to be due to low dietary intake which was inadequate to meet their energy requirements. The country's investment in Research & Development (R&D) on high-yielding varieties of rice and wheat and lab-to-land agriculture extension education, ushered in the Green Revolution; India achieved self-sufficiency in food production within a decade[38]. This enabled the country to initiate:

- Food-for-work programme and provision of food grains at subsidised cost to families below the poverty line to improve household food security; and
- the Integrated Child Development Services (ICDS) to:
  - provide food supplements to children to bridge the gap between energy requirement and dietary energy intake to prevent under-nutrition,
  - screen children for under-nutrition, and
  - provide double rations of food supplements to under-nourished children to improve their nutritional status[7,9].

India has been self-sufficient in food production for the last five decades[9]. Growing realisation of the importance of consuming an adequate balanced diet with diverse grains, pulses, vegetables and fruits for maintaining optimal nutrition and health led to the initiation of the National Food Security Mission to improve grain and pulse production and the National Horticultural Mission to improve vegetable production to meet the needs of the growing population[9]. India enacted the National Food Security Act (NFSA) in 2013 to further improve household food security[10]. The NFSA provides subsidized food grains as a legal entitlement to 2/3rd of Indians; it also provides subsidised food grains for the food supplementation programme under ICDS. India has been one of the fastest-growing economies in the world and achieved the MDG targets for poverty reduction by 2012[9]. Poverty and food insecurity are no longer major factors associated with under-nutrition in children in the country.

DIETARY ENERGY INTAKE IN CHILDREN AND INTRA-FAMILY DIFFERENCES IN NUTRITIONAL STATUS

Over the last few decades, there have been changes in socio-economic status, physical activity and dietary intake. NNMB surveys indicate that there had been:

- a steep reduction in physical activity in work, domestic, and transport domains due to mechanisation and
- a concurrent but lower reduction in the energy intake of adults[14] (Figure 1).

The steep reduction in physical activity and consequent reduction in energy requirements without commensurate reduction in energy intake is a major factor responsible for the rise in prevalence of over-nutrition in adults[7,9].

The Expert Committee on Nutrient Requirements[19] reviewed the emerging dual nutrition burden especially in adults, recent research findings on the nutrient requirements in different age groups and made appropriate recommendations.

Body weight is a major determinant of nutrient requirements. Taking into account the current high under-nutrition rates across age groups in India, the Expert Committee took as reference body weight:

- the mean body weight of the MGRS standards for under-five children, and
- the mean + 2SD of the actual weight of 5-18 year children and adults reported by NNMB surveys,

and computed estimated average requirements (EAR) for the reference population. However, the actual average weight of the population is lower. When EAR for energy for children and adults were computed using actual average weight from NNMB surveys and compared with the actual energy intake from the NNMB surveys, the gap between EAR and actual intake was quite low in pre-school children (Table 1). It is therefore unlikely that low energy intake was the major factor responsible for the high prevalence of under-nutrition in under-five children.

The NNMB surveys in the 1990s had shown that in about a third of the families surveyed, adults had adequate energy intake but energy intake in under-five children was inadequate[14]. Poor child feeding and caring practices might play a role in the observed increase in stunting and underweight rates in children between 12 and 23 months of age. By 36 months children may have learnt to eat sufficient amount of family food to meet their energy requirements from the three meal, one snack family eating practices. This might be responsible for the small reduction in underweight and stunting rates in children beyond 36 months of age. Recent research studies have shown that prevalence of stunting, underweight and wasting were higher in children whose elder siblings were stunted, underweight or wasted[22,25]. This could be because the siblings from the same family shared the factors responsible for under-nutrition. Follow-up studies of younger siblings showed that when they became older, their nutritional status was similar to the earlier recorded nutritional status of their elder siblings[25]. These data suggest that the reported differences between two under-five siblings form the same family were mainly due to the age-related changes in the nutritional status of under-five children. A majority of the families in the country are currently food secure, and nutrition education on the importance of providing appropriate and adequate

- complementary food in 6-11 months, and
- family food 4-5 times a day in 12-23 months

may help in reducing the rise in stunting and underweight rates in children in the 6-23 months of age.

LOW BIRTHWEIGHT

Birth weight is an important determinant of survival, health and growth. Size at birth varies between ethnic groups and countries; within countries there are variations depending on socio-economic status, maternal nutrition and obstetric problems. Low birthweight could be due to poor intra-uterine growth or prematurity or both. In the 1960s and 70s data, mostly from developed countries, showed that neonates with a birth weight below 2500 g (low birthweight LBW) had higher morbidity and mortality as compared to those born with a birth weight of 2500 g or above. Based on these findings the WHO had defined LBW neonates as a high-risk group requiring hospitalisation and intensive neonatal care[39,40].

Five decades ago in India, LBW prevalence was above 40%[26,27]. Over 80% of deliveries occurred at home and neonatal and maternal mortality rates were high. Neonatal care was

available only in a few secondary and tertiary hospitals and neonatal mortality rates (NNMR) were high[15]. It was impossible to provide hospitalisation or intensive neonatal care to all LBW neonates (40%). Research studies reported that Indian neonates survived if given essential newborn care, warmth and breast-feeding. Only neonates who were born prior to 37 weeks, weighed <2 kg at birth or were ill (10-15% of all neonates), were at high risk of morbidity and mortality and required intensive care[26,27]. These results were subsequently confirmed by several studies in India. The country:

- drew up and implemented national guidelines for the detection and management of high-risk neonates requiring intensive care using India-specific functional criteria based on morbidity and mortality rates in relation to birth weight and gestational age from research studies, and
- optimally utilized available healthcare facilities to provide intensive care to 'at risk' neonates.

This effort initially resulted in a reduction in the hospital NNMR. As the health infrastructure at primary, secondary and tertiary care expanded, access to antenatal care, institutional deliveries and neonatal care improved. Concurrently there was a progressive improvement in neonatal mortality demonstrating the validity and advantages of using the functional criteria to provide appropriate neonatal care[15,37].

Over decades there has been a progressive increase in birthweight in many developed countries. For eg the mean birthweight of Canadian neonates in the last decade was about 3.4 kg. The median birth weight of preterm births at 35 weeks was 2.5 kg and of mature small for gestational age (the tenth centile of term infants) neonates was 3 kg. Canada faced the problem that if the criteria of <2.5 kg was used to define 'high-risk' neonates, many preterm and small-for gestational-age Canadian neonates will be classified as normal and may not get the intensive neonatal care needed. Given the wide variations in birthweight between countries, it might be appropriate that each country defines the birthweight below which the risk of morbidity and mortality increased and provide needed clinical care[42].

Over the last four decades there had been efforts to improve access to nutrition and health care to pregnant women and bring about reduction in LBW. All the national health and nutrition surveys show that during the last two decades there had been:

- a progressive reduction in maternal under-nutrition;
- some improvement in maternal weight gain in these short statured women (mean height 151 cm weight gain about 8 kg);
- progressive increase in coverage under antenatal care; and
- some reduction in anaemia.

Data from national surveys cannot be used to assess time trends in prevalence of low birthweight because till 2010 majority of deliveries in occurred at home and birthweight was not recorded. Currently between 80 and 90% of births occur in institutions. But the accuracy, timeliness in measuring and reporting of birthweight are still sub-optimal. Research studies estimate currently that birthweight is below 2500 g in about a third of the neonates[43-45]. It is

estimated that early detection and effective management of maternal under-nutrition, anaemia in pregnancy and pregnancy-induced hypertension can bring about a 3-5% reduction in LBW. Low parental stature, a major factor associated with low birthweight in India, cannot be rapidly modified through interventions. It is therefore unlikely that, in the near future, there will be a substantial reduction in LBW rates[41]. Despite the continued high prevalence of LBW, there has been a steady and sustained reduction in neonatal and infant mortality (NNMR and IMR)[37]. The country had achieved the MDG targets for IMR reduction[9]. Available projections indicate that though India will not be able to achieve the target of 30% reduction in LBW envisaged in the SDG, the country is likely to achieve the targets for IMR reduction[9].

MONITORING GROWTH

There are wide variations in human growth not only between countries, but also between segments of the population in the same country. These variations may in part be due to biological factors such as parental stature[46]. Five decades ago, inadequate dietary intake and the nutritional toll of infections were major factors associated with poor child growth in developing countries. Height and weight were objective parameters which could be used for monitoring growth trajectory in children. Clinical and public health research studies over decades had investigated the growth of children with the view to disaggregate the "normal variations in growth" which are not associated with ill health, from variations due to deficient or excessive dietary intake which can lead to ill health[46].

Research studies in the 1950s showed that the growth of young children could be assessed by plotting weight (measured using a spring balance) against age (in months) of the child; the trajectory of growth of the individual child could be established by plotting weight for age for three consecutive months. Any deviation (mostly dip) from the trajectory of weight for age provided early warning of growth faltering which could lead to under-nutrition. During 1960s and 70s, these road-to-health charts were used in both hospital and community settings for monitoring child growth. Using these charts, the Delhi research team was able to demonstrate that birth weight was a major determinant of growth during 0-59 months of age and low birthweight infants grew along a lower trajectory as compared to infants with birthweight ≥2.5 kg[26,27]. However, monthly follow-up and weighing children over months for detection of under-nutrition was not feasible either in hospital or community settings. There was a felt need for assessing nutritional status of children at any point in time by comparing child's measurements with standards of weight and height for age.

DEVELOPMENT OF CHILD GROWTH STANDARDS

Research studies in the 1970s mostly based on data from developed countries showed that in pre-school children the variations in growth among well-nourished children between countries were relatively small as compared to the differences associated with social class. Therefore, it was suggested that global standards could be developed and used for assessing nutritional status of children across countries[47]. The WHO adopted the National Centre for Health

Statistics (NCHS) height and weight standards based on the growth of bottle-fed children from the United States of America (USA) (who were presumed to have optimal growth)[48]. During the 1980s the WHO NCHS standards were used globally to assess growth and grade nutritional status of under-five children. In the 1990s there was a growing awareness about the importance of breast-feeding as a determinant of growth in infancy. The WHO undertook a multicentre study on growth of breast-fed children (MGRS)and developed the growth reference standards[49]. Taking cognisance of the emerging problem of dual nutrition burden across countries and the need to grade both under- and over-nutrition in children, especially in countries with high stunting rates, the WHO MGRS evolved BMI for age standards[49]. The WHO MGRS standards had been accepted and used in India for the assessment of growth and nutritional status of children.

GROWTH OF UNDER-FIVE CHILDREN

Growth curves for height, weight and BMI for children between 0-59 months computed from NFHS 3, AHS and DLHS 4 showed that:

- the median height and weight for age for Indian children were along the -2 SD trajectory for height and weight of WHO MGRS standards; the 2.3 centile of the height and weight of Indian children were below the -5 SD of the WHO MGRS standards (Figures 2 and 3);
- the median BMI for age in Indian children was near the WHO mean BMI for age or a little lower. The 2.3 centile of the BMI for age of Indian children was around -4SD of the WHO values for BMI for age and 0.01 centile of BMI for age of Indian children was on -5 SD of the WHO values (Figure 4);
- there were no deviations in the growth trajectory for height, weight or BMI in Indian children with increasing age (Figures 2, 3 and 4).

Growth pattern of children from the high-income groups (who were unlikely to have faced food insecurity or poor access to healthcare), did not match the WHO MGRS standards. The differences between growth trajectory of Indian children and WHO MGRS standards were of higher magnitude as compared to the differences in growth trajectory between socio-economic groups in the country. Available limited data from longitudinal follow-up of urban low-middle-income group children living in the community without any special health or nutrition interventions showed that they grew along the -2SD of WHO MGRS standards for height and weight for age and there was no dip in the growth trajectory with increasing age[50]. The lower trajectory of growth in Indian children in comparison with the WHO growth standards in relation to height, weight and BMI continues throughout childhood and adolescence and is responsible for the observed difference in the height and weight between adults in India and developed countries.

The major reason for the concern about the lower growth trajectory in pre-school children is the reported association between poor growth and higher morbidity and mortality. The small statured Indian infants and children growing along a lower trajectory as compared to the WHO MGRS standards did not have higher morbidity due to infections or mortality[33,6] and did not require any intervention. Indian children require interventions only when they deviate from their trajectory of growth.

PREVALENCE OF UNDER-NUTRITION OF UNDER-FIVE CHILDREN BY WEALTH QUINTILES

The prevalence of stunting and underweight in children in the lowest wealth quintile was nearly double as compared to the highest quintile. This might be partly due to the differences in birthweight and partly due to inadequacies in the dietary intake of the children from different wealth quintiles. The differences in prevalence of wasting in children between the wealth quintiles was much smaller because differences in weight and height for age between wealth quintiles were essentially similar (Figure 5). Wasted children in the lowest wealth quintile were predominantly short, underweight and wasted; wasted children from highest quintile were of normal height or tall, had lower weight for their height and had low BMI for age. The relatively high stunting rates in segments of population who had not suffered poverty or food insecurity over generations confirm that short stature in Indian children is not related to food insecurity. The Food and Agriculture Organisation (FAO) had recognised that in South Asia, food insecurity is not the major factor responsible for under-nutrition[28]. Though South Asia is one of the worst affected regions from climate change, FAO's projections show that by 2030 there will be a reduction in the proportion of Asians who are food insecure[51].

The widespread perception that under-nutrition is linked to poverty and food insecurity has led to continued use of stunting and wasting as indicators of food insecurity and recommendations that there should be a further increase in dietary intake of pre-school children to achieve improvement in their nutritional status. Data from the New Delhi Birth Cohort study had shown that under-five children who cross their BMI trajectory were at higher risk of becoming overweight adults and incurring the risk of hypertension and diabetes early in adult life[52]. The message that providing additional food to short children with normal BMI will not improve linear growth but may lead to over-nutrition and adverse health consequences must be transmitted to the nutrition and health care providers and parents. In the dual nutrition burden era, programmes aimed at improving nutritional status should focus on identifying wasted children, providing food supplements regularly to them and monitoring improvement in their nutritional status.

CHANGES IN PREVALENCE OF UNDER-NUTRITION IN RELATION TO AGE

In India, breast-feeding is nearly universal; over two thirds of the infants were solely breast-fed up to six months. India has already achieved the SDG target for 2030 that '50% of the infants should be exclusively breast-fed at 6 months' and is striving to achieve near universal exclusive breast-feeding at 6 months[9]. Prevalence of morbidity due to infections was low in the first few months of infancy. Prevalence of underweight, stunting and wasting which were high right at birth continue to be high in the first six months but, there was no increase in the prevalence of wasting. There was a progressive slow increase in underweight rates between 3 to 24 months. The rise in stunting began later and was steeper (Figure 6). The increase in stunting and underweight in the first year was attributed to poor infant and young child feeding practices (too early introduction of breast milk substitutes, too late introduction,

inadequate quantity and quality of complementary feeds) and an increase in morbidity due to infections. Nutrition and health education to improve exclusive breast-feeding in the first six months and adequate complementary feeding thereafter are being provided through all channels of communication to combat the increase in stunting and underweight rates in infancy[50]. The relatively steeper increase in stunting and underweight rates between 12-23 months is thought to be due to inadequate quantity and quality of adult food consumed by the children when they try to adjust to the families' three meals one snack per day practice. Intervention programmes to prevent rise in stunting and underweight rates in the second year have focused on improving the quality, quantity and frequency of feeding adult food to young children and improving access to health care for the treatment of infections[50]. Between 24 and 35 months there was a small fall in prevalence of stunting and underweight rates; between 36 and 59 months stunting rates plateaued. This might be because children in food-secure households learnt to eat adequate quantity of adult food to meet their energy requirements within the family meal pattern as they grow older.

PREVALENCE OF WASTING IN RELATION TO AGE

Prevalence of wasting rates in the first nine months of life was high, because almost a third of the neonates were wasted at birth. As there were not much changes in stunting or underweight rates of children in the first nine months, there was no change in high wasting rates as assessed by BMI for age during infancy (Figure 6). Infants with moderate (BAZ <2) or severe (BAZ <-3) wasting did not have higher morbidity[31] and were not at higher risk of mortality[6] and therefore did not require any intervention. In the second year there was a steep fall in the prevalence of wasting (low BMI for age) because there was a steep rise in stunting and not so steep rise in underweight rates (Figure 6). This fall in wasting rates should not be interpreted as an improvement in the nutritional status of the child.

The WHO MRGS standards provide two parameters for assessing wasting: BMI for age which varies with age and weight for height which is an age-independent indicator. Most of the Demographic and Health Surveys use weight for height as the parameter for assessing the wasting rates, perhaps because of problems in accurate assessment of age in some countries. The NFHS[16] used weight for height, while AHS[18] and DLHS4[20] used BMI for age for assessing wasting.

At each age group, the prevalence of wasting (both moderate and severe) as assessed by weight for height was higher as compared to the wasting rates assessed by BMI for age (Figure 7). Reduction in wasting and maintaining wasting rates below 5% are SDG targets to be achieved by 2030. Wasting rates in countries, and regions are being tracked as part of the monitoring of progress towards SDG targets. There is a need to ensure that both the global and national reports indicate the parameter used (weight for height or BMI for age) for monitoring the progress towards SDG target for wasting in children, so that this could be taken into account while computing the progress achieved. The WHO MGRS documented that BMI varies with age, especially in the critical 0-23 months. It might therefore, be appropriate to shift to BMI for

age for assessing wasting rates in pre-school children.

TIME TRENDS IN PREVALENCE OF UNDER-NUTRITION

Data from NNMB surveys and NFHS 3-5 showed that over the last four decades there had been a slow but sustained reduction in stunting and underweight but there was not much change in wasting rates (Figures 8 and 9). The estimated average reduction in stunting rates was about 1%/year. Low parental stature and low birthweight are the major factors responsible for stunting and underweight and it is not possible to bring about rapid improvement in these two factors. It is, therefore unlikely that there will be a rapid decline in stunting and underweight rates. There has not been much of a change in wasting rates over time. This is because over time the magnitude of change in weight for age and height for age were similar; BMI for age which is the ratio between weight and height has not shown any substantial change over time. There is increasing recognition that stunting, underweight and wasting rates in India are not related to food insecurity either at the national or at the household level[7,28]. India has been food secure for four decades and will be food secure in 2030 but is unlikely to achieve the SDG targets for reduction in stunting and wasting by 2030.

TIME TRENDS IN SEVERE UNDER-NUTRITION

In the second half of the last century, chronic under-nutrition due to inadequate dietary intake and repeated infections and acute exacerbation of chronic under-nutrition in young children, usually precipitated by severe untreated infection associated with high mortality rates were seen in all developing countries. Sub-Saharan African countries reported that children between 1-2 years of age who were weaned off breast-feeding developed malignant malnutrition (kwashiorkor) associated with high case fatality rates. Research studies from India showed that kwashiorkor occurred in older children between 2-3 years of age, subsisting on breast milk and inadequate quantities of adult food with low energy and micronutrient density. In these chronically under-nourished children, severe infections, mostly diarrhoea, precipitated kwashiorkor. Management of infection with antibiotics saved lives: case fatality rate in India was below 10%[29]. Providing semi-solid calorie-dense food prepared from locally available food stuffs consumed by families such as milk, banana, sugar, roasted cereals (rice and wheat), and lentils (Bengal gram) brought about improvement in nutritional status and children could be discharged from hospitals. Long-term follow-up studies showed that relapses were common as families were food insecure and the child did not get adequate food. Many children died before the age of 5 years due to infections because the families did not have access to health care for treatment of infection[29]. With improvement in access to health and nutritional services there was a reduction in severe under-nutrition. Since 1990s kwashiorkor was rarely reported in India.

In India prevalence of moderate (WHZ <-2) and severe (WHZ<3) wasting had been and continues to be high (Figure 10)[30]. Wasting rates (WHZ<-2 and <-3) were the highest in the under six month children, showed a gradual fall till 18 months and then plateaued. Most of the Indian children with weight for

height z scores below -3 were low birthweight neonates who were growing along a low trajectory of height, weight and weight for height. Very few had severe infections or pedal oedema. Follow up of children admitted in the hospital with weight for height z score <-3 with infections showed that the mortality rates were less than 2%. Children were discharged when they started eating, gained weight and were no longer ill. Follow-up of such children in the community showed that even in the absence of any special care about a third of them improved and became moderately wasted[34-36].

MORBIDITY AND MORTALITY RATES IN RELATION TO NUTRITIONAL STATUS OF CHILDREN

Five decades ago, data from India and other developing countries showed that under-nutrition was associated with immune depression and increased susceptibility to infections; repeated and untreated infections aggravated under-nutrition; under-nutrition was the underlying factor in half of the under-five deaths[3,4]. Health and nutrition intervention programmes aimed at early detection and effective management of both under-nutrition and infections, so that the pace of reduction in both under-nutrition and under-five mortality can be accelerated[8,9]. A recent community based mixed longitudinal study showed that prevalence of infections in urban low middle income pre-school children was high. Increase in risk of infection in children who were under-nourished compared to those who were normally nourished prior to infection was small. These children lived in over-crowded households, in areas with poor environmental hygiene and high air pollution. It is possible that infection rates in children were mainly determined by these factors and excess risk due to under-nutrition was relatively small. The deterioration in nutritional status following infection was small because of ready access to and utilization of health and nutrition care[31-33].

Despite high low birth weight and under-nutrition rates, infant and under five mortality rates had been relatively low. This had been called the 'South Asian Enigma'[11]. Analysis of data from research studies and surveys over the last three decades suggest that relatively low mortality[6] in Indian neonates and children might be because these under-nourished children did not suffer from any functional decompensation and they had access to essential newborn care. The sustained reduction in under-five mortality in India despite high prevalence of under-nutrition and morbidity due to infections might be due to improvement in access to health and nutrition services[6,37]. India was able to achieve the MDG target for infant and under-five mortality. Though the country is unlikely to achieve SDG targets for reduction in low birthweight, stunting and wasting, the country is likely to achieve targets set for infant and under-five mortality reduction for 2030[9].

MANAGEMENT OF SEVERE ACUTE MALNUTRITION (SAM)

In the 1990s prevalence of severe acute malnutrition (SAM) with high mortality rates continued to be high in sub-Saharan Africa partly due to HIV infection and partly due to food insecurity associated with natural and manmade disasters. To assist countries in the management of SAM children, the WHO guidelines for management of SAM were first drawn up in 1999[53] and subsequently updated/revised in 2007 and 2013[54,55]. The

focus of these guidelines was on community-based screening to identify SAM children, refer them to hospital and management of SAM in hospital and community settings. It was estimated that in 2022 only 7.3 million of the 45 million SAM children received treatment. In response to the call from the Global Action Plan on Child Wasting, WHO in 2023 developed comprehensive guidelines for prevention and management of acute malnutrition highlighting the vital importance of investing in both prevention and management[56]. These guidelines recognised that severe wasting may be acute or acute exacerbation of chronic or merely chronic wasting. The WHO 2023 guidelines[56] recommend that "children who are 6-59 months of age with severe acute malnutrition (as assessed by weight for height z score of <-3) who have good appetite, are clinically well and alert can be treated in community settings. Only children who have medical complications, severe oedema, poor appetite (fail in the appetite test) or present with one or more danger signs in childhood should be admitted and treated in hospitals. They could be discharged when their medical complications were treated, their appetite had returned, and they were alert; further management of under-nutrition can be continued in community settings and improvement in nutritional status monitored".

PROTOCOL FOR MANAGEMENT OF UNDER-NUTRITION IN INDIA

Review of Indian data on prevention detection, management of under-five children with moderate and severe wasting in 2022 showed that:

- stunting, underweight and wasting in India were not related to food insecurity;
- majority of Indian children with weight for height z scores below -2 or -3 were low birthweight neonates who were growing along a low trajectory of height, weight and weight for height;
- moderate under-nutrition was not associated with any increase in risk of infections; and
- health care for infection was available and utilised; therefore, mortality rates were low.

In October 2023 Ministry of Women and Child Development Government of India released a standardised national 'Protocol for Management of Malnourished Children'[57].
The protocol recommended that:

- all children with weight for age or weight for height <-3 or <-2, with normal appetite and no medical complications are to be provided with food supplements as envisaged under the ICDS programme (Table 2); these children are to be followed up and improvement in nutritional status monitored.
- children with weight for age or weight for height <-3 who had poor appetite, those who had been losing weight (>10% of earlier body weight), had infection were to be admitted to hospital and given intensive care and appropriate energy-dense food. Once the infection is controlled, appetite returns and there is weight gain, these children can be discharged from the hospital.

After discharge from hospital, these children are to be followed up in community setting and be provided with food supplements as envisaged under the ICDS programme, and improvement in nutritional status monitored carefully.

Table 2 Food supplements for under-nourished children							
Age group	Type of meal	Cereals & millets (g)	Pulses & legumes (g)	Nuts & seeds (g)	Cooking oils (g)	Egg (nos)	WMP (g)
6-12 mths	THR	30	15	12	7.5	1	10
1-3 yrs	THR	60	30	20	15	1	20
3-6 yrs	MS+HCM*	50	25	10	10	0	0
	THR	30	15	12	7.5	1	10
MS+HCM* should have GLV 25 gms other veg 50 gms							
THR Take Home rations; HCM hot cooked meals; MS morning snack; GLV green leafy vegetables; WMP whole milk powder							

This protocol is to be operationalised within the existing health and nutrition programmes and will cover the entire country in a phased manner. Effective implementation of this protocol is expected to accelerate the reduction in under-nutrition rates in pre-school children.

INTERVENTIONS TO IMPROVE NUTRITIONAL STATUS

While assessing nutritional status of growing children and providing appropriate intervention their height, weight and BMI for age should be considered together. This is especially important in India with high prevalence of stunting and some increase in over-nutrition rates in under-five children. Irrespective of their height and weight for age status:

- children with normal BMI do not require any intervention.
- children with low BMI for age, require additional energy intake from home food and supplementary feeding under ICDS; improvement in their body weight and BMI should be monitored. With adequate dietary intake and freedom from infections reversal of wasting can be expected within three months.
- children with high BMI for age should be encouraged to play and run. Those consuming high-fat, high-sugar snacks habitually, will have to be weaned from the practice and taught to consume more vegetables and some seasonal fruits. Their food consumption patterns, physical activity and body weight should be carefully monitored and those showing improvement in BMI should be encouraged to continue their new life style.

These simple interventions could be carried out by all frontline workers both in the ICDS and health systems and can go a long way in combating dual nutrition burden in children.

Conclusion

Indian neonates are born with low weight, length and BMI; they follow a lower trajectory of growth throughout childhood. This is the major factor responsible for the high under-nutrition rates in Indian children. India undertook health risk assessment in relation to birth weight and nutritional status in under-five children. Based on the evidence from these studies, the country drew up and implemented country specific programmes for management of neonatal, infant and child care. Despite continued high low birthweight rates and high under-nutrition rates, the

country achieved MDG targets for reduction in under-five mortality. The current protocol for management of moderate and severe under-nutrition in pre-school children envisages community-based management of under-nutrition within the available ICDS and healthcare systems and monitoring improvement. Hospitalisation is recommended only for those children with loss of appetite, weight loss and/or infections. Effective implementation of the protocol is possible within the existing programmes and will lead to acceleration in decline in under-nutrition and under-five mortality.

In India WHO standards (WHO NCHS and WHO MGRS) had been used to:

- assess nutritional status of children (national, regional, state and different population groups in the country) over time;
- screen children for early detection and effective management of under-nutrition;
- assess impact of ongoing intervention programmes to combat under-nutrition; and
- track changes in nutritional status of children over time.

India is entering the era of dual nutrition burden in children. Assessment and grading of nutritional status of children using global standards will have to continue to:

- track ongoing nutrition transition in under-five children,
- monitor the impact of interventions, and
- monitor progress towards SDG targets.

Concurrently, there is a need to invest in research studies:

- to define functional parameters for assessment of health risk in the dual nutrition burden era,
- to evaluate their usefulness as screening tools in health care setting, and
- to operationalise screening, early detection and effective management of dual nutrition and health problems in children through the existing health and nutrition programmes.

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