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Review Article

Child Malnutrition in Low-Income and Middle-Income Countries: Insights from India

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Abstract

Nutritional influences during early life can have a lasting impact on the growth, health and cognitive and social development of an individual. Undernutrition during this phase can lead to increased susceptibility to infectious diseases, decreased learning capacity, and increased risk of non-communicable diseases in children. Stunting is one of the core indicators of childhood undernutrition and is associated with high morbidity and mortality especially from respiratory tract infections, diarrheal diseases, malaria and measles. Stunting can also affect cognitive development and school performance during childhood and decreased productivity and lower earnings in adulthood. In India, about 38% of the children under five years of age are stunted according to the recent National Family Health Survey (NFHS)-4. To add to the burden, about 21% and 36% of the children under 5 are wasted and underweight respectively. Suboptimal feeding practices are one of the main reasons for the increasing burden of undernutrition in India. Only 55% of the children under the age of 6 months are exclusively breastfed and timely introduction of complementary feeding in infants is very poor. Furthermore, most infants do not receive minimum dietary diversity, minimum meal frequency and minimum acceptable diet. Thus, there is a dire need to encourage and educate mothers about appropriate infant and young child feeding practices. Food fortification and supplementation programs have been found to be effective in tackling micronutrient deficiencies in children and the Government should take necessary actions to make sure that these programs reach every undernourished child within the country.

Keywords: *Undernutrition in Children; Stunting; Wasting; Nutritional Status in India; Nutrition Interventions; Feeding Practices*

Introduction

Nutrition has profound effects on health during the entire lifespan of an individual and is strongly linked with growth, health, cognitive and social development, especially during early childhood. Children are unable to attain their full growth and development potential due to insufficient material and social resources. This could lead to many consequences, including increased susceptibility to infectious diseases, decreased learning capacity, and increased risk of non-communicable diseases. Stunted linear growth is one of the main indicators of childhood undernutrition and has important consequences on health and development [1]. The 13-year Comprehensive Implementation Plan (2012-2025) on Maternal, Infant and Young Child Nutrition was proposed at the 2012 World Health Assembly; and has six global nutrition targets. The first of these global targets is 40% reduction in the number of stunted children under 5 years of age by 2025 [2]. Recently, there has been a global increase in the number of children affected by excessive body weight relative to length or height. If not reversed, childhood obesity can have vast implications not only in terms of healthcare expenditures, but also for the overall development of nations [1].

During the past seven decades, there has been a remarkable shift in the nutritional scenario in India. Although the clinical manifestations of severe malnutrition have reduced with improved food security and healthcare facilities, the decline in chronic undernutrition and micronutrient deficiencies was relatively slow [3]. Malnutrition among under-5 children is considered a major threat to public health in India, since the prevalence of underweight children in India is among the highest in the world [4]. Furthermore, malnutrition in India is a concentrated phenomenon with relatively small number of states and districts accounting for a large share of the burden of malnutrition. Ten percent of villages and district account for nearly 27 - 28% of the burden of underweight children in the country and one-fourth of the districts and villages account for more than half of all underweight children [5]. Despite several nutritional intervention programs, the burden of undernutrition in under-5 children have not changed much. Changing dietary patterns and lifestyle is also affecting the nutrition status of under-5 children, leading to increased prevalence of obesity and chronic non-communicable diseases. This phenomenon is termed as double burden of malnutrition and is one of the emerging crisis in most developing countries [3,6]

Childhood underweight, stunting, and wasting

Undernutrition comprises stunting, wasting and micronutrient deficiencies, which represent one end of the spectrum of malnutrition disorders. Obesity and overconsumption comprise the opposite end of this spectrum [7].

According to the 2016 United Nations Children's Fund (UNICEF), WHO and World Bank Group joint child malnutrition estimates, malnutrition rates in children remain alarming as stunting is declining too slowly and the burden of overweight children continues to rise. The prevalence of stunting has decreased from 39.6% to 23.2% from 1990 to 2015 with nearly 156 million children still affected by stunting (Figure 1). There is limited progress in Africa with only 17% reduction in stunting rates since 2000; Asia and Latin America have cut stunting rates by over one third since 2000 (-36% and -39% respectively). However, Asia and Africa bear the largest share of stunted children with more than half of all stunted children under five living in Asia and more than one third of all stunted children under five living in Africa. The global estimates of wasting and severe wasting in children under five is 50 million and 17 million respectively. The prevalence of wasting in Southern Asia is approaching a critical public health emergency with nearly 14.1% of children under five wasted [8].

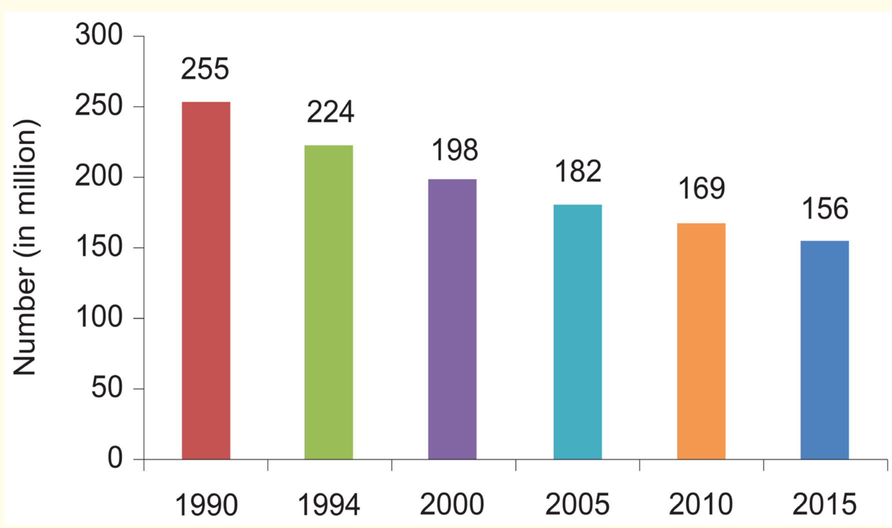

Figure 1: *Global trends in number (millions) of children with stunted growth: 1990-2015 (Adapted from UNICEF/WHO/World Bank Joint Child Malnutrition Estimates, 2016) [8].*

The number of under-5 children who were underweight in 2015 has been estimated to be 93.4 million with a prevalence rate of 13.9%. The highest prevalence of underweight under-5 children was noted in Southern Asia (27.2%) and South-Central Asia (26.3%) The overall prevalence of underweight in developing countries is estimated to be 15.4%. In Asia, the prevalence of underweight in 2015 was estimated to be 16.9% [8]. In India, the under-5 stunting, wasting, and underweight rates were 38%, 21% and 36% respectively according to the most recent National Family Health Survey (NFHS)-4 conducted in 2015 - 2016. The Rapid Survey on Children (RSoC) conducted in 2013 - 2014 also reported almost similar stunting rates (38.7%) and lower wasting and underweight rates (15.1% and 29.4% respectively). There has been a significant improvement in stunting, and underweight rates in India compared to the data from the NFHS-3 conducted in 2005 - 2006 (stunting, and underweight rates were 48% and 43% respectively) although wasting rate has worsened by 1%. According to NFHS-4, the percentage of stunted children was considerably higher in rural areas (31 vs. 41.2%), in children from the lowest wealth quintile (51 vs. 22%), a trend similar to the NFHS-3 survey. More children from rural areas (38.3 vs. 29.1%) and lowest wealth index (49 vs. 20%) were underweight. Education and caste were some of the key indicators determining the child's nutritional status [9-11].

Impact of stunting

Stunting is associated with high morbidity and mortality especially from infectious diseases such as respiratory tract infections, diarrheal diseases, malaria and measles. Mortality risk is increased in stunting due to secondary immune suppression and increased susceptibility to infections associated with poor growth [12]. Stunting is also associated with reduced physical growth, reduced neurodevelopmental function, and increased risk of chronic diseases in later life [13]. Growth failure during early childhood has been found to be associated with reduced stature in adulthood; risk of overweight during later childhood and risk of elevated blood pressure, glucose and lipid levels in adulthood [14,15]. Stunting can affect development of higher cognitive processes during childhood. In a study in Indian children, stunted children performed poor on tests of attention, working memory, learning and memory etc. suggesting a generalized cognitive impairment [16]. Stunting in the first 2 years of life is associated with less schooling and lower performance in tests of reading and nonverbal cognitive skills [17]. In addition, stunting has also been linked to lower earnings and productivity in adulthood which can be averted by stunting reduction [18].

Most of the stunting occurs within First 1000 days of life, i.e., from conception to the age of 2 years since the child's linear growth is most sensitive to nutritional changes and environmental stress during this period. It is worth emphasizing that the largest proportion of the stunting occurs during infancy and toddlerhood (6 - 23 months) and therefore adequate complementary feeding during this period plays a critical role in achieving optimal physical growth and brain development in children [19].

Under-5 child deaths attributable to nutritional disorders: Global and Indian estimates

Under-5 mortality is one of the common measures of the population health [20]. Suboptimum growth that is indicated by stunting, wasting, and underweight increases the risk of death from infectious diseases in childhood. Recent analysis by Black., *et al*. showed that all anthropometric measures of undernutrition were associated with increased risk of death from diarrhea, pneumonia, and measles, but not malaria. The number of deaths in children attributable to different growth indices were estimated globally using the UN and Nutrition Impact Model Study (NIMS) prevalence data. According to the UN prevalence data, stunting and underweight were associated with the highest proportions of attributed child deaths (14% for both) and wasting accounted for 12.6% of child deaths. According to the NIMS prevalence data, stunting and underweight individually accounted for 17% of child deaths and wasting accounted for 11.5% of child deaths (Table 1) [1].

	Attributable deaths with UN prevalences*	Proportion of total deaths of children younger than 5 years	Attributable deaths with NIMS prevalences#	Proportion of total deaths of children younger than 5 years
Fetal growth restriction (< 1 month)	817000	11.8%	817000	11.8%
Stunting (1 - 59 months)	1017000*	14.7%	1179000#	17.0%
Underweight (1 - 59 months)	999000*	14.4%	1180000#	17.0%
Wasting (1 - 59 months)	875000*	12.6%	800000#	11.5%
Severe wasting (1 - 59 months)	516000*	7.4%	540000#	7.8%

Table 1: *Global deaths in children younger than 5 years attributed to nutritional disorders (Adapted from Black., et al. 2013) [1].*

*Data are to the nearest thousand. *Prevalence estimates from the UN. #Prevalence estimates from Nutrition Impact Model Study (NIMS)*

The under-5 mortality in India has shown a downward trend over the past two decades according to the NFH surveys (Figure 2). According to the recent estimates from the NFHS-4, under-5 mortality rate is 50 per 1000 livebirths, more so in rural areas compared to the urban areas (56 vs. 34 per 1000 livebirths) [10]. A nationally representative mortality survey for the period 2001 - 2003 in India suggested that the five leading causes that accounted for 62% of all child deaths were pneumonia, prematurity and low birth weight, diarrheal diseases, neonatal infections, birth asphyxia, and birth trauma [21].

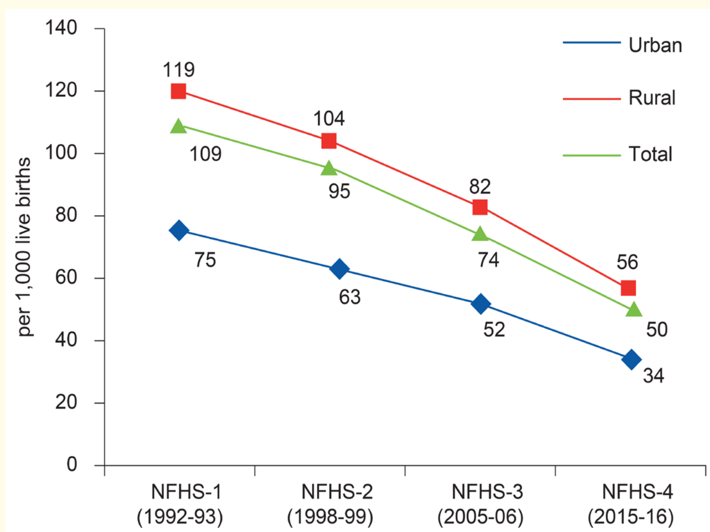

Figure 2: *Trends in under-5 mortality (Deaths per 1,000 livebirths) (NFHS-4, 2016) [10].*

Burden of overweight/obesity in children

Undernutrition has been the focus of nutrition agendas in low- and middle-income countries (LAMICs) in the past. However, rapid economic development and urbanization has led to a transition in lifestyle and nutrition resulting in an increase in obesity and related chronic diseases [22]. Childhood obesity is increasing at an alarming rate in children, especially in the LAMICs [23]. According to the 2016

UNICEF, WHO and World Bank Group joint child malnutrition estimates, nearly 42 million children under 5 were overweight in 2015, which reflects an increase of about 11 million over the past 15 years (Figure 3). The number of overweight children has increased rapidly in LMICs. Almost half of all overweight children younger than 5 years lived in Asia in 2015 and one quarter lived in Africa [8]. There is a lack of national representative data on the burden of childhood obesity in India. However, a recent systematic review indicated that the prevalence of obesity in under-5 children from India was below 2% in most studies. The rates of overweight were two times higher and seemed to be higher in northern and eastern India than in southern India [24].

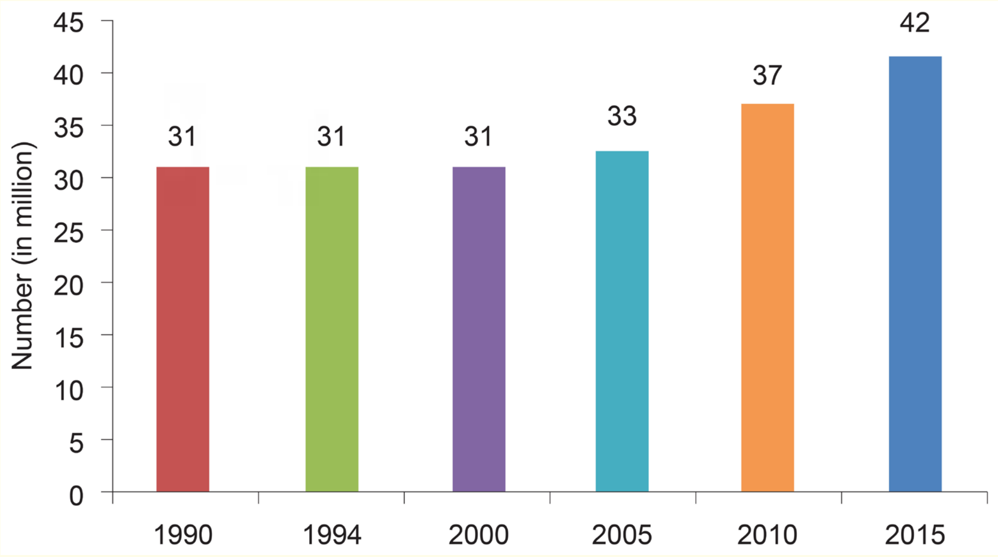

Figure 3: *Global trends in number (millions) of children who are overweight: 1990-2015 (Adapted from UNICEF/WHO/World Bank Joint Child Malnutrition Estimates, 2016) [8].*

Micronutrient Deficiencies (MND)(malnutrition) in children

Micronutrient deficiencies (MND) are widespread globally, and pregnant women and children under 5 years of age are at the highest risk. Deficiency of iron, iodine, folate, vitamin A, and zinc are the most common MNDs and contribute largely to poor growth, intellectual impairments and increased risk of morbidity and mortality. The LMICs have the highest burden of MNDs due to poverty although it can also occur in certain population groups in higher-income countries [25].

Iron and Folate

Iron is a critical nutrient for normal growth, immune function, brain development and development of cognitive function. Iron deficiency anemia (IDA) is the most common MND that affects more than 30% of the world's population. Pregnant women are at highest risk for IDA due to increased demand for fetal growth and development. Maternal iron deficiency can thus have deleterious effects on the child. The child born to an iron-deficient mother is more likely to have low iron stores, impaired physical as well as cognitive function, and suboptimal immune system [25].

According to the WHO, about 43% of children (273 million) worldwide had anemia in 2011. More than half of the children in South-East Asia and African regions (53.8% or more) were reported to have anemia, and severe anemia was highest in the African region (3.8%). In addition, the greatest number of children with anemia resided in the South-East Asia region corresponding to nearly 97 million children [26]. According to the NFHS-4, the percentage of children aged 6-59 months who were anemic was 58.4 with more number of children in urban areas compared to rural areas (59.4 vs. 55.9%) [10]. The prevalence of IDA in young children (6 - 23 months) has been reported to be nearly 50%. Children living in poor households in rural areas are particularly affected but prevalence is high even in wealthy urban households [27].

The association between folate deficiency during periconceptional period and neural tube defects are well known [28]. Deficiencies of folate along with vitamin B_{12} may contribute to poor growth and excess morbidity in many low- and middle-income countries [29]. There is no nationwide data on the prevalence of folate deficiency in children in India. In a study conducted amongst children of 5 - 18y in National Capital Territory of Delhi, prevalence of folate deficiency was observed in 42% and 30.7% for children in the age group of 5 - 11 years and 12 - 18 respectively [30].

Adverse consequences of iron deficiency in India

The effects of iron deficiency observed within the first six months of life can lead to a permanent brain damage [31]. Iron deficiency has several non-hematological consequences based on its severity, including impaired immune and cognitive function, compromised growth and development, and reduced work capacity, athletic performance and scholastic performance. In a study conducted in adolescent girls in a rural school situated in central India, all the components of cognitive function scores (mathematics score, multi-component test scores, and Intelligent Quotient [IQ] scores) were lower in iron-deficient, (both anemic and non-anemic groups), than non-iron deficient non-anemic group [32]. The total lifetime costs of IDA in children aged 6 months - 59 months amounted to intangible costs of 8.3 million Disability Adjusted Life Years (DALYs) and the production losses were 24,001 USD which is equal to 1.3% of gross domestic product [27].

Strategies for Addressing Iron and folate Deficiency in India

Prevention of iron deficiency and IDA requires robust strategies that address all the potential causative factors. Interventions to prevent and correct iron deficiency and IDA should thus include methods to ensure iron intake through food-based approaches (dietary diversification and food fortification), iron supplementation, and improved health services and sanitation. Encouraging the consumption of micronutrient-rich foods such as dark green leafy vegetables, lentils, and vitamin C-rich fruits forms an essential part of dietary diversification [33]. Apart from breast milk, folic acid is available in dark-green vegetables and legumes which are consumed in small quantities especially in urban poor [29]. Studies suggest that diets of Indian children aged 6 months to 3 years lack sufficient energy intakes as well as intake of essential micronutrients such as iron, calcium, and zinc [34-36]. Complementary foods fed to children aged 13-24 months was predominantly cereals with only small amount of vegetables or fruits [37]. The cereal-based foods limit the bioavailability of iron due to the presence of phytates [38]. The dietary iron absorption from habitual Indian diets (rice-based, mixed cereal-based, wheat/millet-based) in children ranges from 2% to 5% [39]. Thus, it is difficult to meet the recommended intake of iron intake with staple diets unless meat, poultry, or fish is added [33]. This may not be feasible in families that consume vegetarian diets only. Consumption of foods rich in vitamin C such as fruits, juices, potatoes along with foods rich in iron may be one of the strategies to increase the absorption of iron. It is also important to educate households on food preparation practices that may reduce the consumption of iron absorption inhibitors [33].

Fortification of foods is a long-term strategy which covers a larger population compared to supplementation that is targeted towards certain individuals and groups requiring immediate attention. Fortification requires policy and procedural changes and support from the food industries and thus requires more time for implementation. Food fortification is beneficial when MND is widespread since fortification has the capacity to reach the most within a country [25]. Fortification of infant formulas and infant cereals, addition of micronutrient powders to home-made complementary foods or iron drops are some of the strategies that can be used in weaning infants [40]. In a study by Krebs., *et al*. in 2006 which included 88, exclusively breastfed infants who received either pureed beef or iron-fortified infant cereal as their first complementary food from 5 to 7 months of age, a significantly higher intake of iron was observed in the iron-fortified cereal group compared to the meat group (7.2 vs. 1.5 mg/day) at 7 months [41]. In a study conducted in children aged 6 to 24 months in Sangam Vihar, North Delhi, India, fortified complementary foods demonstrated a 67% reduction in proportion of children with anemia ((Hb < 10 g/dL) compared to a 27% reduction fortified sprinklers group [42].

Supplementation is one of the key steps towards addressing iron deficiency and IDA. The National Iron + Initiative 2013 has proposed an anemia supplementation program across the life cycle in which the beneficiaries will receive both iron and folic acid (IFA) supplementation irrespective of their iron or hemoglobin status. These interventions are based on WHO recommendations, global evidence on IFA supplementation, and the recommendations of national experts. According to this initiative, the recommendations for IFA supplementation in children are as follows:

1. In children aged 6 - 60 months, 1 mL of IFA syrup containing 20 mg of elemental iron and 100 mcg of folic acid should be given bi-weekly throughout the period of 6 - 60 months. Deworming should be done for children 12 months and above.
2. In children aged 5 - 10 years, tablets of 45 mg elemental iron and 400 mcg of folic acid should be given weekly throughout the period of 5 - 10 years of age with bi-annual deworming.
3. In children/adolescents aged 10 - 19 years, 100 mg of elemental iron and 500 mcg of folic acid should be given weekly throughout the period of 10 - 19 years of age with bi-annual deworming.

The supplementation program has been proposed to be implemented through the Accredited Social Health Activist (ASHA) on fixed days on a biweekly basis. In addition, an extensive communication campaign has been developed to bring about behavioral change in terms of dietary habits and compliance [33].

Vitamin A

Vitamin A deficiency (VAD) has many health implications, including severe anemia, night blindness, wasting, reproductive or infectious morbidity, and high risk of mortality. Visual disturbances due to VAD are rampant in low-income countries of South Asia [43]. According to the 2016 UNICEF report, one in three children aged under five (29%) were deficient in vitamin A in 2013. The highest rates of VAD has been reported in South Asia and sub-Saharan Africa where nearly half of the children under 5 are affected [44]. India has been reported to have the highest prevalence of clinical and subclinical VAD among South Asian countries. Nearly 62% of preschool children were reported to be deficient in Vitamin A and 31% to 57% of them to be victims of subclinical VAD [43]. Recent estimates suggest that there has been virtual disappearance of keratomalacia and a decline in Bitot spots in India attributed to an efficiently functioning universal vitamin A supplementation (VAS) program [45].

Strategies for addressing vitamin A deficiency

Dietary diversification, supplementation, and fortification are some of the viable approaches for eliminating VAD. Vitamin A supplementation is one of the most effective and widely used strategies in low-income countries [43]. The national VAS coverage in India increased from less than 20% in 2000 to 60% - 79% in 2015, affected [44]. Recently, several concerns have been raised regarding universal supplementation of high-dose vitamin A in India since VAD is now limited to isolated geographical regions [46]. Thus, in Indian scenario, it is prudent to restrict massive dose prophylaxis to isolated geographical regions afflicted with clinical VAD rather than continuing universal prophylaxis. At this point, food-based approaches are a sustainable and cost-effective solution to combat VAD in non-clinically deficient areas in India. This can be achieved by increasing local production and consumption of green leafy vegetables and plant foods that are rich in carotenoids. In order to optimize the VAS program, the "Triple A" (Assessment, Analysis, and Action) strategy should be adopted; where the problem of VAD is assessed, the causes are analyzed and the approaches to be adopted are decided [45].

Zinc

Zinc plays a vital role in normal body functioning, including gene expression, cell division, immunity, and reproduction. Nearly 17% of the world's population have inadequate zinc intake with substantial regional variation; Asia and Africa have the highest prevalence (19.4% and 17.3%, respectively) [47]. Maternal zinc deficiency has been linked to behavior abnormalities in the offspring, impaired immune system and elevated blood pressure in the offspring [48]. Infections such as Shigellosis, Campylobacteriosis, *Escherichia coli* infection, *Staphylococcus aureus* infection, and cholera are widely reported among children in developing countries. Although they are not direct outcomes of zinc deficiency, likelihood of these infections is reduced through zinc therapy [49]. A recent community-based cross-sectional study of under-5 children belonging to low socio-economic status in 5 states of India (Uttar Pradesh, Karnataka, Orissa, Gujarat, and Madhya Pradesh) estimated the overall prevalence of zinc deficiency to be 43.8%. The prevalence of zinc deficiency was highest in Orissa (51.3%) and the lowest in Karnataka (36.2%) [50].

Strategies for combating zinc deficiency

Supplementation, fortification, and dietary diversification are some of the strategies for enhancing zinc status among various population groups. However, no planned national-level zinc supplementation programs have been launched in any of the South Asian countries. Zinc fortification in South Asian developing countries is not well-planned despite its positive effects on total zinc absorption and enhanced zinc status in populations. Dietary diversification involves consumption of meat, poultry, or fish which are good sources of readily-available zinc. Appropriate selection of foods, modifying traditional methods of food preparation and focused food production are important considerations for supply of zinc through this approach. This approach holds potential benefits in developing countries since it is cost-effective, sustainable, and is culturally acceptable [49].

Iodine

Iodine is an essential micronutrient and is utilized for the synthesis of thyroid hormones which play a key role in metabolism, development and tissue differentiation [51]. Deficiency of iodine has critical consequences during fetal development and childhood and can result in still birth, miscarriages, poor growth, and cognitive impairment. Other manifestations of iodine deficiency include hypothyroidism, goiter, cretinism, poor school performance, impaired intellectual ability and work capacity. Iodine deficiency constitutes world's greatest single cause of preventable brain damage [52]. Evidence suggests that children living in iodine-deficient areas have a lower intelligence quotient by nearly 13.5 points compared to those living in areas with adequate iodine intake [53]. The WHO data on the global estimates of iodine deficiency in 2007 suggested that 31.5% of school-age children accounting for 266 million had insufficient iodine intake. In nearly 47 countries iodine deficiency is a public health problem and this includes both developed and developing countries [52]. In 2011, 241 million school-aged children globally had inadequate iodine intakes [54]. In India, 337 districts out of 414 districts surveyed are endemic for iodine deficiency where the prevalence of iodine deficiency disorders (IDD; a spectrum of disorders related to iodine deficiency) is more than 5% [55].

The most widely used strategy to control iodine deficiency is universal salt iodization [52]. According to the NFHS-4 survey, 93.1% of household in India are using iodized salt indicating a significant rise compared to the NFHS-3 survey where only 76.1% of households used iodized salt [9,10]. Andhra Pradesh (82%), Tamil Nadu (83%), and Dadra and Nagar Haveli (71%) reported lowest use of iodized salt. The aim of the National Iodine Deficiency Disorders Control Programme (NIDDCP) run by the Government of India is to bring the prevalence of IDD to below 5% in the country and to ensure 100% consumption of adequately iodized salt [55].

Special situations and child nutritional status

Nutrition in preterm/low-birth-weight infants

Preterm birth is the second highest direct cause of death in children under 5 years of age. In 2010, a total of 14.9 million (range 12.3 - 18.1 million) preterm births were reported globally. More than 60% of preterm births were reported in South Asia and sub-Saharan Africa which accounts for 52% of global live births [56]. The prevalence of low birth weight infants (< 2500g) ranges from 15% to 20% globally and in India, the estimate was 18.6% according to the RSoC survey 2014 [11,57]. The percentage of LBW infants according to the NFHS-3 was 22% suggesting a dismal improvement of less than 4% in the past decade [9]. The prevalence of LBW was similar in urban and rural areas in India although more children belonging to low wealth index were born with low birth weight [9]. The small for gestational age (SGA) infants in n low- and middle-income countries in the year 2010 accounted for 27% of all live births. India has the highest number of SGA births (12.8 million) constituting 46.9% of all live births [58].

Inadequate postnatal nutrition in preterm infants is an important factor that can contribute to growth failure due to major protein and energy deficits during neonatal hospitalization. Early aggressive nutrition therapy is one of the strategies of nutrition support in preterm infants to reduce caloric and protein deficit in the acute stage as much as possible to prevent extrauterine growth restriction (EUGR) and abnormal neurodevelopmental outcomes [59]. In a study by Stephens., *et al*. first-week protein and energy intake after birth was associated with developmental outcomes at 18 months in 'extremely low birth weight' infants. The study showed a 4.6-point increase in mental development index for every 10 kcal/kg/day of energy intake and an 8.2-point increase for every gram per kilogram per day of protein intake [60].

Challenges in feeding preterm infants

Feeding of preterm and LBW infants may be relatively difficult as majority of preterm infants are born with inadequate feeding skills and may require other feeding methods such as spoon or gastric tube feeding. Many are prone to significant illnesses in the first few weeks of life and the underlying condition often precludes enteral feeding. Very low birth infants (< 32 weeks) have low body stores of nutrients since intrauterine nutrient accretion occurs in the later phase of third trimester. Nutrient supplementation may be needed in such infants and in term LBW infants who are likely to be growth restricted. Preterm infants are more likely to experience feed intolerance due to gut immaturity and may require additional monitoring and treatment [61].

Types of feeds for preterm infants

There are significant benefits of mother's milk for preterm infants; it can reduce necrotizing enterocolitis (NEC) and late-onset sepsis. Mother's milk may also be beneficial in sensory-neural development in preterm infants. Unless contraindicated, mother's milk should be the first-choice feed for preterm infants. However, unsupplemented mature human milk may not provide sufficient quantity of protein to support the growth and lean body mass accretion in extreme preterm infants. Human milk fortifiers (HMFs) can be a useful addition to meet nutrient requirements of preterm infants [59].

Fortification of human milk increases the nutrient content of milk without compromising on its benefits. Experimental evidences suggest that the net nutrient retention achieved with HMF is similar to or more than the expected intrauterine rates of accretion in preterm infants [61]. Infant formulas are a major source of nutrition during hospital stay when human milk is not available. Since standard infant formulas are designed for term infants and are similar to the composition of mother's milk, they do not provide sufficient quantities of nutrients for a preterm infant. Preterm formulas are specially designed for preterm infants and have energy content similar to breast milk (20 kcal/oz or 67.6 kcal/100 mL) and is enriched with proteins (2.0 g/100 mL), minerals, vitamins, and trace elements. Preterm formulas marketed in India and many other countries usually provide 24 kcal/oz or 80 kcal /100mL. Higher energy formulas (24 kcal/oz [81 kcal/100 mL] and 30 kcal/oz [101 kcal/100 mL]) are also available [59]. Pasteurized donor human milk is another option when mother's milk is unavailable or insufficient. Considering India has a high rate of preterm births with significant morbidity and mortality, human milk banks can be beneficial [62].

Diarrhea and nutrition

Diarrhea was one of the leading causes of death in children aged 1-59 months in India [21]. In the NFHS-3, nearly 9% of under-5 children had diarrhea in the two weeks preceding to the survey which increased to 9.2% in the NFHS-4 survey. However, RSoC 2014 reports that only 6.5% of under-5 children had diarrhea 15 days preceding to the survey [9-11]. The occurrence of diarrhea has been reported to be highest in the age group of 6 - 11 months (49.1% and 36.4% in two studies respectively) [63,64]. The relationship between diarrhea and malnutrition is bidirectional; diarrhea leads to malnutrition and malnutrition worsens the course of diarrhea. Reduced intake, maldigestion, malabsorption, increased loss of nutrients, and the effects of inflammatory response are some of the contributing factors for the detrimental effects of diarrhea on nutritional status [65].

The impact of diarrhea on growth has been studied in large groups of children. In the Global Enteric Multicenter Study, children with moderate-to-severe diarrhea experienced a substantial nutritional insult, indicated by linear growth faltering. Furthermore, the children grew significantly less in height in the 2 months following the episode compared to their age- and gender-matched controls. Children with a single episode of moderate-to-severe diarrhea had a 8.5 times higher risk of death within 2 months [66].

Nutritional strategies for children with diarrhea

The essential elements in diarrhea management include rehydration therapy, zinc supplementation, and counselling for continued feeding and prevention. Oral rehydration therapy with oral rehydration salts (ORS) is the "gold standard" of diarrhea management. The UNICEF and WHO recommend that all children should receive ORS to prevent and treat dehydration due to diarrhea. When ORS is not available, other fluids (home-made sugar-salt solutions, cereal-based drinks) can be used. Breast milk is an excellent rehydration fluid in children who are still breastfeeding. Children with diarrhea should be continued to be breastfed as breastfeeding shortens duration of the diarrhea and improves energy intake [65,67]. Zinc supplementation is the next essential element of diarrhea management. Zinc supplementation is a simple and effective treatment strategy for the management of acute diarrhea. Administration of zinc supplements reduces the duration and severity of diarrhea and the likelihood of subsequent occurrence during the next 2 - 3 months [68]. In addition, it is also important to ensure appropriate feeding practices and optimum feeding frequency during diarrhea to ensure absorption of sufficient nutrients for weight gain and to prevent the onset of malnutrition [69]. The majority of children with persistent diarrhea may have intolerance to lactose and the WHO recommends low lactose feeds for persistent diarrhea [70,71]. Medium-chain triglycerides (MCT) are fat-based foods which may be given as supportive nutritional therapy in children with diarrhea to increase the caloric value of the food and improve its palatability, digestion and absorption [72]. Nucleotides are non-protein nitrogenous compounds that are possibly beneficial in diarrheal diseases, but there are no recent studies that confirm their benefits in the management of diarrhea [72,73].

Influence of nutrition on allergy and atopic diseases

Although atopic diseases have a genetic basis, environmental factors, particularly early infant nutrition, can have a significant impact on the development of atopic disease [74]. Evidences suggest that exclusive breast-feeding during the first 3 months of life is associated with lower incidence of atopic dermatitis and asthma during childhood in children with a family history of atopic diseases [75,76]. Similarly, exclusive breastfeeding for a minimum of 4 months in infants who are at risk of developing atopic diseases is associated with a lower cumulative incidence of cow milk allergy until 18 months of age [77].

Studies have investigated the effect of timing of introduction of complementary foods on the development of atopic disease in breastfed or formula-fed infants. The European Academy of Allergology and Clinical Immunology has recommended a delayed introduction of solid foods for 4 to 6 months in breastfed or formula-fed infants [77]. However, there are conflicting results from other studies which demonstrate no benefits with delay in the introduction of complementary foods [78,79]. Cow's milk is also one of the leading causes of allergy in infants and young children with a reported prevalence of 2% to 3% in infants [80]. Cow's milk protein allergy (CMPA) is not uncommon in a developing a country like India and Poddar., *et al*. reported a mean age of diagnosis at 17.2 ± 7.8 months and the mean duration of symptoms of 8.3 ± 6.2 months [81]. Early identification and management of CMPA is essential to prevent nutritional deficiencies and ensure proper growth and development [80].

There is modest evidence on the benefits of extensively or partially hydrolyzed formulas to delay or prevent atopic dermatitis in children who are not exclusively breastfed for 4 to 6 months compared to cow milk formula. Studies suggest that extensively hydrolyzed formulas may be more beneficial than partially hydrolyzed formulas in preventing atopic disease. More studies are needed to determine whether these benefits extend into late childhood and adolescence [74].

Barriers to improving child nutrition: Indian context

According to the UNICEF Global Nutrition Database, 2012, less than 40% of children globally are exclusively breastfed. The percentage of infants less than 6 months of age who were exclusively breastfed in South Asia was 47% [82]. According to the NFH-4 report, nearly 55% of the children under the age of 6 months are exclusively breastfed which suggests a positive trend from the NFHS-3 report that suggested exclusive breastfeeding rates of 46%. Furthermore, nearly 41% of the children were breastfed within an hour of birth in the NFHS-4 report compared to 23.4% in the NFHS-3 report. According to the NFHS-3 report, in India, only 29.4% of urban children were breastfed within an hour of birth and almost half of the rural children did not start breastfeeding within the first day of birth. Interestingly, in the NFHS-4 report, breastfeeding rates within an hour of birth was similar in both urban and rural areas suggesting increased awareness about breastfeeding in the urban areas [9,10]. According to the RSoC survey 2014, nearly 65% of children aged 0-5 months were exclusively breastfed and 44.2% in the rural areas and 45.6% in the urban areas initiated breastfeeding within the first hour of delivery [11]. There is a need for improvement in the quality of maternal care by training health-care providers and strengthening systems to promote optimal breastfeeding practice [82].

Cow's milk is one of the most common weaning foods in India [83]. According to the RSoC survey 2014, nearly 25% of breast-fed and 54% of non-breast-fed children aged 0 - 23 months were given milk other than breast milk (cow/goat milk) [11]. In one study by Mayuri., *et al*. cow's milk was initiated in children at as early as 3 months of age despite advice by the health care practitioners against feeding initiating cow's milk to children less than 1 years of age. Furthermore, dilution of cow's milk before boiling was a common practice which may compromise the nutrient content of the milk [84]. Early introduction of cow's milk can have several health implications including iron deficiency anemia, allergy to cow's milk, high renal solute load, nutritional imbalance, risk for type 1 diabetes mellitus [85].

Complementary feeding practices in India are very poor. According to the RSoC survey, timely introduction of complementary feeding among infants aged 6-8 months was seen only in 51% of children. Children from urban areas were more likely to receive complementary foods compared to children from rural areas (58 vs.47%). The minimum dietary diversity was seen in only 20% of the children and only 36% of the children were fed a minimum number of times. The minimum acceptable diet in both breastfed and non-breastfed children was just 11%. Mother's education and wealth index were some of the factors associated with better feeding practices [11]. The NFHS-4 survey also reported that only 9.6% of children (both breastfed and non-breastfed) aged 6 - 23 months received an adequate diet [10]. A secondary analysis study of NFHS-3 report suggested that minimum dietary diversity, minimum meal frequency and minimum acceptable diet was seen in 15.2%, 41.5% and 9.2% respectively. Lack of maternal education, lower maternal body mass index (BMI < 18.5 kg/m2), lower wealth index, less frequent (< 7) antenatal clinic visits, lack of post-natal visits, and poor exposure to media were some of the determinants of not meeting minimum dietary diversity and minimum acceptable diet in children in the NFHS-3 [86].

One of the other barriers that is often linked to nutritional deficiencies is picky eating behavior and neophobia in children between 1 to 5 years of age. Picky eating is described as constant unwillingness to try new foods or having strong food preferences/choice of food groups [87]. A cross-sectional study conducted in Indian and Australian mothers suggested that at least 50% of mothers in both cohorts did not feed their children responsively and commonly followed non-responsive feeding practices, namely dietary restriction, pressure and passive feeding [88]. Responsive feeding is important for child development. In many communities in India, children are often left to feed themselves and the caregivers do not offer encouragement. A highly active approach is needed in such settings where the mothers recognize the signs of hunger and satiety and improve dietary intakes [89]. Picky eating has been found to be twice as likely to be associated with underweight children (at 4.5 years), consumption of less vitamins and minerals, consuming less fruits and vegetables and with a distorted nutrient composition of the diet [90-92]. Neophobia describes the tendency for children to initially reject novel foods. Neophobia may result in poor diversity in dietary patterns and children with such a condition may rarely prefer fruits and vegetables resulting in consequent poor intake of these foods [93]. Children who were introduced to complementary foods before 6 months of age were more likely to develop neophobia [87]. Repeated exposure to new foods in a non-coercive setting can help improve children's preferences for and acceptance to new foods [93].

Educational interventions can significantly improve infant and young child feeding practices. A cluster randomized trial in India evaluated the impact of teaching caregivers on appropriate complementary feeding and strategies of feeding responsively through home visits and how they would increase children's dietary intake compared to home-visit-complementary feeding education alone or routine care. Community-based educational interventions were significantly associated with increased intake of nutrients, reduced stunting and improved mental development scores in children under two years compared to routine care [94]. In another study by Bhandari., *et al.* training of health and nutrition workers on exclusive breastfeeding and complementary feeding practices in children under two years was associated with positive outcomes with respect to exclusive breastfeeding rates and higher coverage for vitamin A, iron and folic acid supplementation [95].

Food fortification is one of the commonly used methods to improve nutrition in many countries. The government of India recommended food fortification in the 10th, 11th, and 12th Five-year plans through implementation of existing government nutrition programs [96]. Wheat, milk and oil fortification, complementary food fortification, salt iodization are some of the programs implemented in many states of India [97].

Future Prospects and Conclusion

The prevalence of undernutrition children in India is among the highest in the world. Despite implementation of several programs aimed at improving nutrition on a large scale, the burden of undernutrition remains burgeoning. To add to the burden, changing dietary patterns and urban lifestyles have led to an increase in the prevalence of obesity in children. This coupled with growing prevalence of micronutrient deficiencies has led to an increase in the risk of infections and chronic non-communicable diseases. Currently, preterm births and diarrhea are among the leading causes of death in children under 5 years of age worldwide. Considering India has high rates of preterm births and diarrhea is one of the leading causes of death in under-5 children in India, providing nutritional support in these conditions is imperative. Suboptimal feeding practices in India are a major contributor for the increasing burden of malnutrition in India. This needs to be tackled by promoting exclusive breastfeeding and appropriate complementary feeding practices. Health service providers play an important role in promoting feeding practices in infants and young children. Thus, it is essential to train the health service providers on counseling the mothers and caregivers on breastfeeding and complementary feeding as well as on assisting in solving common feeding problems. Implementation of effective nutritional intervention programs requires actions from multiple sectors and at multiple levels. The decision-makers should understand the extent of the burden and identify areas for intervention. This review is an attempt to raise awareness regarding the burden of undernutrition in India and help implement an effective nutritional intervention program in India.

Key Messages

- Nutrition has profound effects on health during the entire lifespan of an individual and is strongly linked with growth, health, cognitive and social development, especially during early childhood. This could lead to many consequences, including increased susceptibility to infectious diseases, decreased learning capacity, and increased risk of non-communicable diseases. Stunted linear growth is one of the main indicators of childhood undernutrition. In India, the under-5 stunting, wasting, and underweight rates were 38%, 21% and 36% respectively according to the most recent NFHS-4. India also has high rates of preterm births and diarrhea is one of the leading causes of death in under-5 children.
- Deficiency of iron, iodine, folate, vitamin A, and zinc are the most common MNDs and contribute largely to poor growth, intellectual impairments and increased risk of morbidity and mortality. About 58% children aged 6-59 months were anemic as per NFHS-4 survey with anemia being more prevalent in urban areas than rural areas. Nearly 62% of preschool children were reported to be deficient in Vitamin A and the overall prevalence of zinc deficiency in under-5 children in India has been found to be 43.8%. Supplementation, fortification, and dietary diversification are some of the strategies used for enhancing micronutrient status of children in India.
- Suboptimal feeding practices in India are a major contributor for the increasing burden of undernutrition in India. According to the NFH-4 report, nearly 55% of the children under the age of 6 months are exclusively breastfed. Timely introduction of complementary feeding among infants aged 6-8 months was seen only in 51% of children. Most infants do not receive minimum dietary diversity, minimum meal frequency and minimum acceptable diet according to the NFHS-4 survey. Furthermore, use of cow's milk as one of the weaning foods in infants aged less than 1 year is a common practice in India which can several health implications.
- Educational interventions can significantly improve infant and young child feeding practices. Community-based educational interventions have been proven to increase intake of nutrients, reduce stunting and improve mental development scores in children. Health service providers should be trained for counseling the mothers and caregivers on breastfeeding and complementary feeding as well as on assisting in solving common feeding problems. In addition, effective implementation of nutritional intervention programs such as food fortification and supplementation programs is necessary to improve nutritional status of children in India.

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Conflict of Interest

None.

Bibliography

1. Black RE., *et al.* "Maternal and child undernutrition and overweight in low-income and middle-income countries". *Lancet* 382.9890 (2013): 16-25.

2. WHO. "Proposed global targets for maternal, infant and young child nutrition". *Geneva: World Health Organization* (2012).

3. Gopalan C. "The changing nutrition scenario". *Indian Journal of Medical Research* 138.3 (2013): 392-397.

4. Sahu SK., *et al.* "Malnutrition among under-five children in India and strategies for control". *Journal of Natural Science, Biology and Medicine* 6.1 (2015): 18-23.

5. Gragnolati M., *et al*. "India's Undernourished Children: A Call for Reform and Action" (2005).

6. Abdullah A. "The double burden of undernutrition and overnutrition in developing countries: an update". *Current Obesity Reports* 4.3 (2015): 337-349.

7. Black RE., *et al.* "For the Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: global and regional exposures and health consequences". *Lancet* 371.9608 (2008): 243-260.

8. UNICEF, WHO, World Bank. "Levels and trends in child malnutrition". Joint child malnutrition estimates. NewYork, NY: United Nations International Children's Fund Geneva: World Health Organization Washington, DC: World Bank (2016).

9. "National Family Health Survey (NFHS-3)". (2005-2006).

10. "National Family Health Survey (NFHS-4)". (2015-2016).

11. "Rapid Survey on Children INDIA". INDIA Fact Sheet (2013-2014).

12. Olofin I., *et al.* "Associations of Suboptimal Growth with All-Cause and Cause-Specific Mortality in Children under Five Years: A Pooled Analysis of Ten Prospective Studies". *Plos One* 8.5 (2013): e64636.

13. Prendergast AJ., *et al*. "The stunting syndrome in developing countries". *Paediatrics and International Child Health* 34.4 (2014): 250-265.

14. Coly AN., *et al.* "Preschool stunting, adolescent migration, catch-up growth, and adult height in young senegalese men and women of rural origin". *Journal of Nutrition* 136.9 (2006): 2412-2420.

15. Stein AD., *et al.* "Childhood growth and chronic disease: evidence from countries undergoing the nutrition transition". Maternal and Child Nutrition 1.3 (2005): 177-184.

16. Kar BR., *et al.* “Cognitive development in children with chronic protein energy malnutrition”. *Behavioral and Brain Functions* (2008): 4-31.

17. Hoddinott J., *et al.* “The economic rationale for investing in stunting reduction”. *Maternal and Child Nutrition* 9.2 (2013): 69-82.

18. Hoddinott J., *et al.* “Adult consequences of growth failure in early childhood”. *American Journal of Clinical Nutrition* 98.5 (2013): 1170-1178.

19. Aguayo VM., *et al*. “Stop stunting: improving child feeding, women’s nutrition and household sanitation in South Asia”. *Maternal and Child Nutrition* 12.1 (2016): 3-11.

20. Black RE. “For the DCP3 RMNCH Authors Group. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities”. 3rd Edition 388.10061 (2016): 2811-2824.

21. Million Death Study Collaborators. “Causes of neonatal and child mortality in India: nationally representative mortality survey”. *Lancet* 376.9755 (2010): 1853-1860.

22. Tzioumis., *et al.* “Childhood dual burden of under- and over-nutrition in low- and middle-income countries: a critical review”. *Food and Nutrition Bulletin* 35.2 (2014): 230-243.

23. Hills AP., *et al.* “Childhood obesity in Asia: the value of accurate body composition methodology”. *Asia Pacific Journal of Clinical Nutrition* 23.3 (2014): 339-343.

24. Ranjani H., *et al.* “Epidemiology of childhood overweight and obesity in India: A systematic review”. *Indian Journal of Medical Research* 143.2 (2016):160-174.

25. Bailey RL., *et al.* “The Epidemiology of Global Micronutrient Deficiencies”. *Annals of Nutrition and Metabolism* 66.2 (2015): 22-33.

26. WHO. “The global prevalence of anaemia in 2011”. *Geneva: World Health Organization* (2015).

27. Plessow R., *et al.* “Social Costs of Iron Deficiency Anemia in 6-59-Month-Old Children in India”. *PLoS ONE* 10.8 (2015): e0136581.

28. Black MM. “Effects of vitamin B12 and folate deficiency on brain development in children”. *Food and Nutrition Bulletin* 29.2 (2008): S126-S131.

29. Strand DA., *et al.* “Vitamin B-12, folic acid, and growth in 6- to 30-month-old children: A randomized controlled trial”. *Pediatrics* 135.4 (2015): e918-e926.

30. Kapil U., *et al.* “Prevalence of ferritin, folate and vitamin B12 deficiencies amongst children in 5–18 years of age in Delhi”. *Indian Journal of Pediatrics* 81.3 (2014): 312.

31. Kotecha PV. “Nutritional anemia in young children with focus on Asia and India”. *Indian Journal of Community Medicine* 36.1 (2011): 8-16.

32. More S., *et al.* “Effects of iron deficiency on cognitive function in school going adolescent females in rural area of central India”. *Anemia* (2013).

33. “National Iron Plus Initiative. Guidelines for Control of Iron Deficiency Anaemia” (2016).

34. Kapur D., *et al.* “Dietary intake and growth pattern of children 9-36 months of age in an urban slum in Delhi”. *Indian Pediatrics* 42.4 (2005): 351-356.

35. Khokhar A., *et al.* "A study on malnutrition among children aged 6 months to 2 years from a resettlement colony of Delhi". *Indian Journal of Medical Research* 57.7 (2003): 286-289.

36. Laxmaiah A*., et al.* "Diet and nutrition". Indian Pediatrics 39 (2002): 331-338.

37. Jani R., *et al*. "Mineral content of complementary foods". *Indian Journal of Pediatrics* 76.1 (2009): 37-44.

38. Christides T., *et al.* "Iron bioavailability and provitamin A from sweet potato- and cereal-based complementary foods". *Foods* 4.3 (2015): 463-476.

39. Madhavan Nair K., *et al*. "Iron content, bioavailability and factors affecting iron status of Indians". *Indian Journal of Medical Research* 130.5 (2009): 634-645.

40. Andersson M., *et al.* "Prevention of iron deficiency in infancy, childhood and adolescence". *Annales Nestle* 68 (2010): 120-131.

41. Krebs NF., *et al.* "Meat as a first complementary food for breastfed infants: feasibility and impact on zinc intake and status". *Journal of Pediatric Gastroenterology and Nutrition* 42.2 (2006): 207-214.

42. Sazawal S., *et al.* "Compliance with home-based fortification strategies for delivery of iron and zinc: Its effect on haematological and growth markers among 6-24 months old children in North India". *Journal of Health, Population and Nutrition* 32.2 (2014): 217-226.

43. Akhtar S., *et al.* "Prevalence of Vitamin A Deficiency in South Asia: Causes, Outcomes, and Possible Remedies". *Journal of Health, Population and Nutrition* 31.4 (2013): 413-423.

44. UNICEF report on Vitamin A Supplementation (2015).

45. Kapil U. "Massive dose vitamin A programme in India - Need for a targeted approach". *Indian Journal of Medical Research* 138.3 (2013): 411-417.

46. UNICEF. "Scaling Up Vitamin A supplementation in India Evidence and Lessons Learned from 15 Major States in India". (2014).

47. Wessells RK., *et al.* "Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting". *PLoS One* 7.11 (2012): e50568.

48. Uriu-Adams JY., *et al.* "Zinc and reproduction: effects of zinc deficiency on prenatal and early postnatal development". *Birth Defects Research Part B Developmental and Reproductive Toxicology* 89.4 (2010): 313-325.

49. Akhtar S. "Zinc Status in South Asian Populations-An Update". *Journal of Health, Population and Nutrition* 31.2 (2013): 139-149.

50. Kapil U., *et al.* "Magnitude of zinc deficiency amongst under five children in India". *Indian Journal of Pediatrics* 78.9 (2011): 1069-1072.

51. Biradar MK., *et al.* "Prevalence of iodine deficiency disorders among 6 to 12 years school children of Ramanagara district, Karnataka, India". *International Journal of Community Medicine And Public Health* 3.1 (2016): 166-169.

52. de Benoist B., *et al.* "Iodine deficiency in 2007: global progress since 2003". *Food and Nutrition Bulletin* 29.3 (2008): 195-202.

53. Bleichrodt N., *et al.* "A meta-analysis of research on iodine and its relationship to cognitive development". In: Stanbury JB, editor. The damaged brain of iodine deficiency - Cognitive behavioral, neuromotor, educative aspects". New York: Cognizant Communication Corporation (1994): 195-200.

54. Andersson A., *et al.* "Global iodine status in 2011 and trends over the past decade". *Journal of Nutrition* 142.4 (2012): 744-750.

55. Ministry of Health and Family Welfare. "National Iodine Deficiency Disorders Control Programme (NIDDCP)" (2018).

56. Blencowe H., *et al.* "National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: A systematic analysis and implications". *The Lancet* 379.9832 (2012): 2162-2172.

57. "WHA Global Nutrition Targets 2025: Low Birth Weight Policy Brief" (2016).

58. Embleton ND., *et al.* "Low-Birthweight Baby: Born Too Soon or Too Small". *Nestle Nutrition Institute Workshop Series. Nestec Ltd* 81 (2015): 1-7.

59. Su BH. "Optimizing Nutrition in Preterm Infants". *Pediatrics and Neonatology* 55.1 (2014):5e13.

60. Stephens BE., *et al.* "First-week protein and energy intakes are associated with 18-month developmental outcomes in extremely low birth weight infants". *Pediatrics* 123.5 (2009): 1337-1343.

61. Sankar MJ., *et al.* "Feeding of low birth weight infants". *Indian Journal of Pediatrics* 75.5 (2008): 459-469.

62. Bharadva K., *et al.* "Human Milk Banking Guidelines". *Indian Pediatrics* 51 (2014): 469-474.

63. Ahmed SF., *et al.* "Prevalence of diarrhoeal disease, its seasonal and age variation in under- fives in Kashmir, India". *International Journal of Health Sciences* 2.2 (2008): 126-133.

64. Jyothi P., "Prevalence of rotavirus diarrhoea in children below 5 years, a pilot study". *International Journal of Current Microbiology and Applied Sciences* 5.8 (2016): 71-74.

65. Nel ED. "Diarrhoea and malnutrition". *South African Journal of Clinical Nutrition* 23.1 (2010): S15-S18.

66. Kotloff KL., *et al.* "Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): A prospective, case-control study". *Lancet* 382.9888 (2013): 209-222.

67. UNICEF. Pneumonia and diarrhoea Tackling the deadliest diseases for the world's poorest children (2012).

68. Khan WU. "Zinc supplementation in the management of diarrhea". WHO (2011).

69. "The Treatment of Diarrhea. A manual for physicians and other senior health workers". WHO (2005).

70. Sachdeva A., *et al*. Advances in Pediatrics 2.1 (2012): 1139-1141.

71. WHO. "Pocket book of hospital care for children: Guidelines for the management of common childhood illnesses. Diarrhoea. 2nd edition". Switzerland: World Health Organization (2013): 125-146.

72. Tanchoco CC., *et al.* "Diet supplemented with MCT oil in the management of childhood diarrhoea". *Asia Pacific Journal of Clinical Nutrition* 16.2 (2007): 286-292.

73. Neri-Almeida D., *et al.* "Lack of effect of nucleotide-supplemented infant formula on the management of acute diarrhea in infants". *Nutrition Research* 29.4 (2009): 244-247.

74. Greer FR., *et al.* "Effects of Early Nutritional Interventions on the Development of Atopic Disease in Infants and Children: The Role of Maternal Dietary Restriction, Breastfeeding, Timing of Introduction of Complementary Foods, and Hydrolyzed Formulas". *Pediatrics* 121.1 (2008): 183-191.

75. Gdalevich M., *et al.* "Breast-feeding and the onset of atopic dermatitis in childhood: a systematic review and meta-analysis of prospective studies". *Journal of the American Academy of Dermatology* 45.4 (2001): 520-527.

76. Gdalevich M., *et al*. "Breast-feeding and the risk of bronchial asthma in childhood: a systematic review with meta-analysis of prospective studies". *Journal of Pediatrics* 139.2 (2001): 261-266.

77. Muraro A., *et al*. "Dietary prevention of allergic diseases in infants and small children. Part III: critical review of published peer-reviewed observational and interventional studies and final recommendations". *Pediatric Allergy and Immunology* 15.4 (2004): 291-307.

78. Morgan J., *et al.* "Eczema and early solid feeding in preterm infants". *Archives of Disease in Childhood* 89.4 (2004): 309-314.

79. Zutavern A., *et al.* "The introduction of solids in relation to asthma and eczema". *Archives of Disease in Childhood* 89.4 (2004): 303-308.

80. Koletzko S., *et al.* "Diagnostic approach and management of cow's milk protein allergy in infants and children: ESPGHAN GI Committee practical guidelines". *Journal of Pediatric Gastroenterology and Nutrition* 55 (2012): 221-229.

81. Poddar U., *et al.* "Cow's milk protein allergy: an entity for recognition in developing countries". *Journal of Gastroenterology and Hepatology* 25.1 (2010): 178-182.

82. UNICEF. "Improving child nutrition The achievable imperative for global progress" (2013).

83. Madhu K., *et al*. "Breast feeding practices and newborn care in rural areas: A descriptive cross-sectional study". *Indian Journal of Community Medicine* 34.3 (2009): 243-246.

84. Mayuri M., *et al.* "Bovine milk usage and feeding practices for infants in India". *Indian Journal Public Health* 56.1 (2012): 75-81.

85. Leung AKC., *et al.* "Whole cow's milk in infancy". *Paediatrics and Child Health* 8.7 (2003): 419-421.

86. Patel A., *et al.* "Determinants of inappropriate complementary feeding practices in young children in India: secondary analysis of National Family Health Survey 2005-2006". *Maternal and Child Nutrition* 8.1 (2012): 28-44.

87. Shim JE., *et al*. "Associations of infant feeding practices and picky eating behaviors of preschool children". *Journal of The American Dietetic Association* 111.9 (2011): 1363-1368.

88. Jani R., *et al.* "Child-feeding practices of Indian and Australian-Indian mothers". *Nutrition and Dietetics* 71.4 (2014): 276-283.

89. Bhandari N., *et al.* "Infant and Young Child Feeding". *Proceedings of the Indian National Science Academy* 82.5 (2016): 1507-1517.

90. Dubois L., *et al.* "Preschool children's eating behaviours are related to dietary adequacy and body weight". *European Journal of Clinical Nutrition* 61.7 (2007): 846-855.

91. Cardona Cano S., *et al.* "Trajectories of picky eating during childhood: A general population study". *International Journal of Eating Disorders* 48.6 (2015): 570-579.

92. Dubois L., *et al.* "Problem eating behaviors related to social factors and body weight in preschool children: A longitudinal study". *International Journal of Behavioral Nutrition and Physical Activity* 4.9 (2007).

93. Perry RA., *et al.* "Food neophobia and its association with diet quality and weight in children aged 24 months: a cross sectional study". *International Journal of Behavioral Nutrition and Physical Activity* (2015): 12-13.

94. Vazir S., *et al*. "Cluster-randomized trial on complementary and responsive feeding education to caregivers found improved dietary intake, growth and development among rural Indian toddlers". *Maternal and Child Nutrition* 9.1 (2013): 99-117.

95. Bhandari N., *et al.* "Use of multiple opportunities for improving feeding practices in under-twos within child health programmes". *Health Policy Plan* 20.5 (2005): 328-336.

96. Liu P., *et al.* "Food Fortification in India: A Literature Review". *Indian Journal of Community Health* 26.S1 (2014): 59-74.

97. WHO. Global Database on the Implementation of Nutrition Action (GINA).

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