

An estimated one third of under-5 children (178 million) are stunted, whereas 112 million are underweight, making malnutrition the most common ‘disease’ of children

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Global Burden of Maternal and Child Undernutrition and Micronutrient Deficiencies
by Tahmeed Ahmed et al.

Key insights

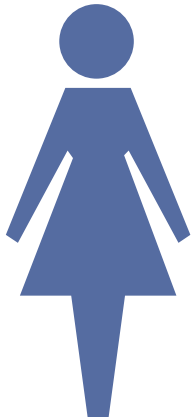
Most women living in developing countries experience various biologic and social stresses that increase the risk of malnutrition of mother and child. It is imperative to control the problem by scaling up direct nutrition interventions as well as addressing female illiteracy, lack of livelihoods, and women’s empowerment.

Current knowledge

Women who are undernourished at the time of conception are unlikely to improve their nutritional status during pregnancy. Many major adult diseases are associated with impaired intra-uterine growth and development. Studies conducted in developing countries on protein-energy malnutrition and micronutrient deficiencies show a substantial impact on mortality and disability-adjusted life years.

Practical implications

Priority interventions include breastfeeding promotion, appropriate complementary feeding, essential vitamins and minerals supplementation, and severe acute malnutrition management. Appropriate care of low-birth-weight infants, including feeding, proper hygiene and sanitation, as well as early detection and treatment of complications, can substantially reduce mortality in this highly vulnerable group.



Priority interventions

- Breastfeeding promotion
- Proper hygiene and sanitation
- Management of severe acute malnutrition
- Essential vitamins and minerals supplementation
- Appropriate complementary feeding
- Literacy, livelihoods, empowerment

Strategies for the prevention of maternal and child undernutrition.

Recommended reading

Ahmed AMS, Ahmed T, Mahfuz M, Abdullah K, Cravioto A: Impact of balanced protein-energy supplementation on pregnancy weight gain and birth weight; in Bhutta ZA (ed): *Nutrition Interventions for Maternal and Child Health and Survival*. Karachi, Oxford University Press, 2010.

Global Burden of Maternal and Child Undernutrition and Micronutrient Deficiencies

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Key Messages

- Despite improvements in health indicators, the global burden of maternal and child undernutrition is still alarmingly high.
- Poverty, food insecurity, ignorance, lack of appropriate infant and young child feeding practices, heavy burden of infectious illnesses, and poor hygiene and sanitation are among the factors that are responsible for the high levels of maternal and child undernutrition in developing countries.
- It is now imperative to control the problem by scaling up direct nutrition interventions and eliminating the root conditions including female illiteracy, lack of livelihoods, and lack of women's empowerment.
- The determinants of low birth weight and stunting need more research so that simple interventions can be developed and implemented.

Key Words

Gender inequities · Food insecurity · Intrauterine growth restriction · Low birth weight · Maternal undernutrition · Micronutrient malnutrition · Protein-energy malnutrition · South Asia

Abstract

Maternal and child undernutrition and micronutrient deficiencies affect approximately half of the world's population. These conditions include intrauterine growth restriction (IUGR), low birth weight, protein-energy malnutrition, chronic energy deficit of women, and micronutrient deficiencies. Although the rates of stunting or chronic protein-energy malnutrition are increasing in Africa, the absolute numbers of stunted children are much higher in Asia. The four common micronutrient deficiencies include those of iron, iodine, vitamin A, and zinc. All these conditions are responsible directly or indirectly for more than 50% of all under-5 deaths globally. According to more recent estimates, IUGR, stunting and severe wasting are responsible for one third of under-5 mortality. About 12% of deaths among under-5 children are attributed to the deficiency of the four common micronutrients. Despite tremendous progress in different disciplines and unprecedented improvement with many health indicators, persistently high undernutrition rates are a shame to the society. Human development is not possible without taking care to control undernutrition and micronutrient deficiencies. Poverty, food insecurity, ignorance, lack of appropriate infant and young child feeding practices, heavy burden of infectious illnesses, and poor hygiene and sanitation are factors responsible for the high levels of maternal and child undernutrition in developing countries. These factors can be controlled or removed by scaling up direct nutrition interventions and eliminating the root conditions including female illiteracy, lack of livelihoods, lack of women's empowerment, and poor hygiene and sanitation.

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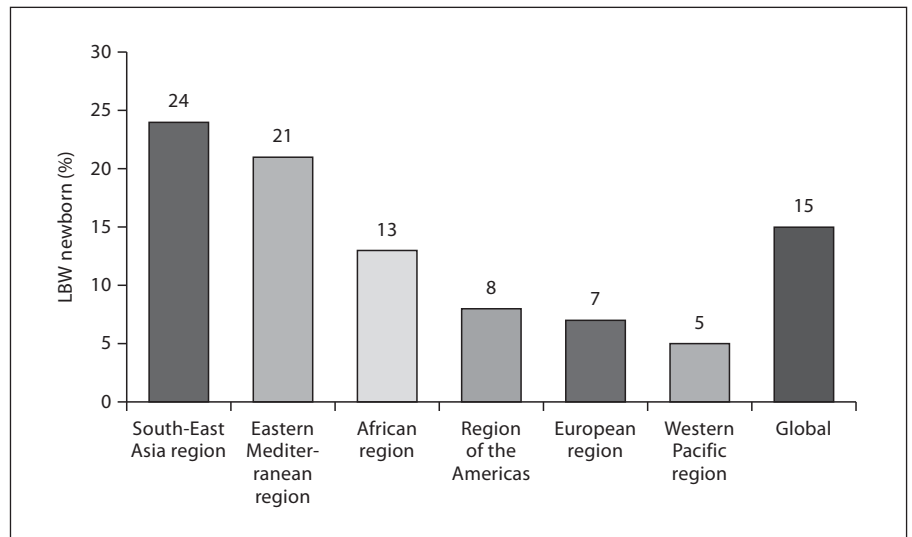


Fig. 1. Percentage of LBW newborns in different global regions over 2005–2010 [51].

Maternal Undernutrition

There is enough food for everybody on earth, yet maternal and child undernutrition is still common and associated with millions of deaths globally every year. Maternal nutrition refers to the nutritional needs of women during antenatal and postnatal periods and sometimes also to the period prior to conception (i.e. during adolescence) [1]. Maternal undernutrition or chronic energy deficit is defined as having a body mass index of <18.5.

Women who are undernourished at the time of conception are unlikely to improve their nutritional status during pregnancy, when they have additional demands due to the growing fetus. They may fail to gain sufficient weight during pregnancy and have a higher risk of mortality than healthy women [2]. In most developing countries, maternal undernutrition is persistent and an important contributor to morbidity, mortality, and poor birth outcomes including low birth weight (LBW) (fig. 1), neonatal mortality, and subsequent childhood malnutrition. Maternal undernutrition (including chronic energy and micronutrient deficiencies) is most prevalent in South Asia, ranging from 10 to 40%. The situation is considered critical in South Asia, and it is remarkable that the prevalence of female undernutrition is consistently higher in Bangladesh than in any other developing country [3] where >30% of women of child-bearing age have chronic energy deficiency [4]. In Pakistan, the prevalence of malnutrition is high both among lactating and pregnant women (16.1%) and their non-pregnant counterparts (12.5%) [5], while in Indonesia, 12–22% women suffer from chronic energy deficiency and 40% of pregnant

women are anemic [6]. These findings are not confined to Asia; in sub-Saharan Africa, only 3 out of 10 countries show a decline in the rate of severe maternal malnutrition (body mass index <16) [7]. In South Asia, maternal malnutrition alone is responsible for 25–50% of intrauterine growth restriction (IUGR) [8]. In this way, undernutrition is handed down from one generation to another and the vicious cycle continues. These children do not experience much catch-up growth in subsequent years, remain vulnerable to diseases, enter school late, do not learn well, and are less productive as adults [9].

Causes of Maternal Undernutrition

Maternal undernutrition remains a persistent problem in developing countries, where women usually fall behind men in having access to food, health care, and education [10]. Bhutta et al. [8], in 2004, showed underlying determinants such as female illiteracy, poverty, and lack of empowerment of women as major barriers to improvement in maternal nutrition in South Asia. A study conducted in Bangladesh also confirms that women's education, exposure to media, and domestic decision-making status all play significant roles in nutritional status of women [9]. Women with low status in societies tend to have weaker control over household resources, tighter time constraints, less access to information and health services, poorer mental health, and lower self-esteem [2], which are key factors that directly influence women's health and nutritional status [11]. Although a national nutrition program in Bangladesh resulted in high levels of knowledge of beneficial nutritional practices, it is

quite challenging for pregnant women to implement such advice due to formidable social and economic barriers [11].

Many women suffer from a combination of chronic energy deficit, poor weight gain during pregnancy, anemia, and other micronutrient deficiencies, as well as infections like HIV, malaria or dengue [1]. Most women living in developing countries experience various biologic and social stresses that increase the risk of malnutrition. These stresses include food insecurity and inadequate diets, recurrent infections, poor health care, heavy work burdens, and gender inequities [9]. An Indian study has demonstrated that excessive work burden and unequal distribution of resources due to lower bargaining power and lack of attention within a household could be contributing to higher rates of chronic energy deficit in Indian women compared to their male partners [12].

The physiological stress of added nutrient demands makes pregnancy and lactation high-risk periods in the life of a woman. The woman's tissues become depleted of essential nutrients as she enters the vicious cycle of too many closely spaced pregnancies. Globally, iron deficiency anemia contributes to 447,000 maternal deaths that equate to 12.9 million disability-adjusted life years (DALYs) [13].

The extra energy needed during pregnancy and lactation represents a small percentage (5 and 8%, respectively) of total household food energy needs [14]. However, when household food insecurity is persistent, even these small amounts of extra food may be unavailable. Even when enough food is available at the household level, the majority of women do not receive adequate nutrients intake during pregnancy. Key contributing factors, including entrenched poverty, gross food insecurity, gender discriminatory food allocation, food avoidances, and lack of access to adequate health services, continue to challenge women's health and nutritional practices [11]. Therefore, to facilitate adequate provisioning of food during pregnancy, lactation, and infancy, national-level actions are needed to reduce the limitations imposed by such barriers.

Prevention and Management of Maternal Undernutrition

Women's nutrition matters not only to women, their children and families, but also to their society, and interventions targeted at improving women's nutrition should

be incorporated into national health strategies without any delay [15]. The interventions should target the most vulnerable age groups. Adolescent girls who are undergoing rapid growth and development are one of the nutritionally vulnerable groups who should receive due attention [16].

Most marriages in developing countries take place during adolescence (the median age at marriage in Bangladesh is 16 years), and conception soon follows marriage. Since one third of adolescent girls are malnourished in developing countries, the risks of IUGR and subsequent child malnutrition form a vicious cycle of intergenerational transfer of malnutrition. This cycle has to be broken by strategies to improve women's nutrition in general and that of adolescent girls in particular for creating awareness and demand for nutrition services [17].

Adolescents should receive information, education, and counseling about their health and nutrition care that can be delivered from community outposts or even classrooms; assessment of existing infrastructures to efficiently address the adolescent girls' reproductive health is also important [17]. In Gujrat, India, supplementation of adolescent girls with iron-folic acid once a week was effective in reducing the burden of anemia and is potentially a scalable intervention [18]. The nutrition-specific or direct interventions that have been highlighted in the Lancet Nutrition Series 2008 for improving maternal nutrition include iron-folic acid or multiple micronutrient supplementation, use of iodized salt, and calcium supplementation [13]. Other important interventions include rest and balanced energy-protein supplementation (additional 700 kcal daily) during pregnancy. Nutrition-sensitive or indirect interventions include those to reduce tobacco consumption and indoor air pollution, deworming during pregnancy, insecticide-treated bed nets, and intermittent preventative treatment for malaria. Improving literacy, women's empowerment, creating livelihoods, and investing in nutrition-friendly agriculture have profound effects

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Improving literacy, women's empowerment, creating livelihoods, and investing in nutrition-friendly agriculture have profound effects on maternal nutrition as well as child nutrition.

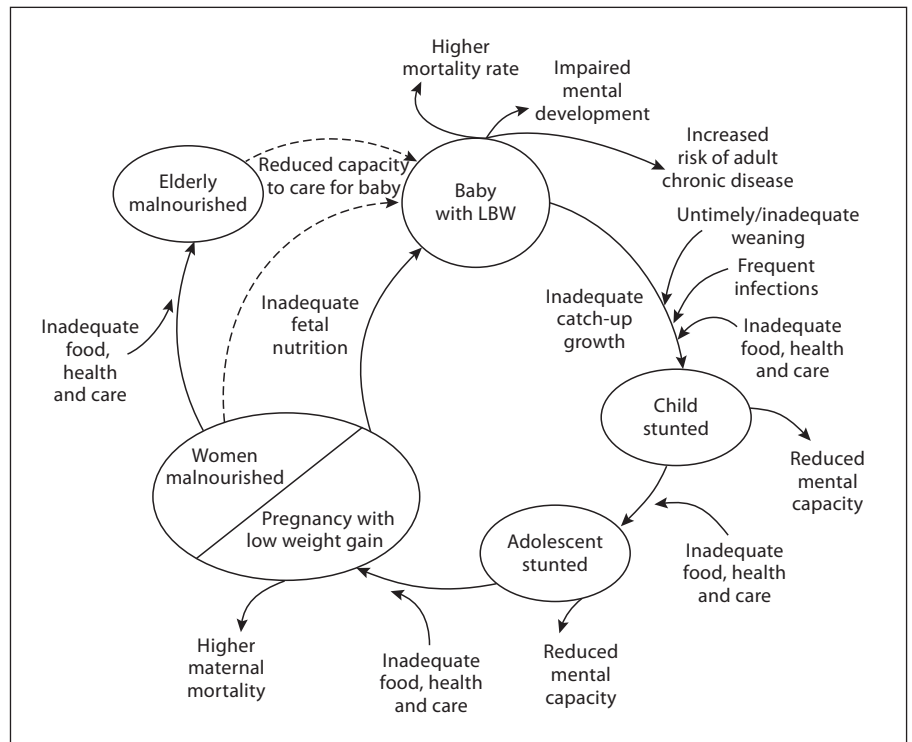


Fig. 2. Nutrition through the life cycle showing the effects of LBW, including increased risk of adult onset diseases [52].

on maternal nutrition as well as child nutrition. Food insecurity refers to the lack of a household’s physical and economic access to sufficient, safe, and nutritious food that fulfills the dietary needs of that household for living an active and healthy life [19]. The Food and Agriculture Organization has estimated that 925 million people are food insecure and do not have enough to eat, and 98% of them live in developing countries. In food-insecure communities, interventions to improve availability and access to safe food need to be implemented. This may include food rations.

Intrauterine Growth Restriction/Low Birth Weight

Neonates born at term (who have completed 37 weeks of gestation) with a birth weight <2,500 g are defined as LBW [20]. LBW can result from preterm delivery or IUGR, or a combination of the two. LBW in the first 2 years of life may lead to irreversible damage, including malnutrition, shorter adult height, lower attained schooling, and reduced adult income [21]. Several major adult diseases, such as coronary heart disease, hypertension, and type 2 diabetes, are associated with impaired intrauterine growth and development, especially when combined with rapid

or excessive growth/weight gain in later childhood [22] (fig. 2). There is a fairly consistent association between LBW and elevated risk of adult hypertension [23]. The global prevalence of LBW is 15.5%, which means that about 20.6 million infants with LBW are born each year, 96.5% of them in developing countries [24]. India alone, with an estimated 33% of all newborns weighing <2,500 g at birth, contributes 40% of the world’s LBW population [25]. LBW and stunting together are responsible for 2.1 million deaths (21% of worldwide deaths in children under 5 years of age) and 91.0 million DALYs (21% of global DALYs for children under 5 years of age; 7% of global total DALYs) [26]. Among all countries across the world, India alone has 0.6 million deaths and 24.6 million DALYs attributed to stunting, severe wasting, and IUGR/LBW [26]. Factors associated with IUGR are shown in table 1.

Prevention of Intrauterine Growth Restriction/Low Birth Weight

To eliminate IUGR and LBW in the longer term, basic nutrition-specific interventions should be supplemented by improvements in the underlying determinants of undernutrition, such as poverty, illiteracy, disease burden, and lack of women’s empowerment. Attaining full growth potential is especially important for women and girls in

Table 1. Factors associated with IUGR [47]

Fetal factors	Maternal factors	Infection	Nutrition	Maternal substance abuse/alcohol consumption	Uterine/placental factors	Demographic factors
Chromosomal abnormalities Congenital abnormalities/syndromes	Medical conditions Pregnancy-induced hypertension Essential hypertension Renal disease Maternal hypoxia (cardiac or pulmonary diseases) Connective tissue diseases	Toxoplasmosis Rubella Cytomegalovirus Herpes virus Malaria HIV	Malnutrition	Cigarette smoking Alcohol Illicit drugs Drugs like anticonvulsants	Placental infarcts Placenta praevia Placental insufficiency Uterine abnormalities Bifid uterus	Low socioeconomic status Maternal height Race Parity Multiple gestations

order to break the intergenerational cycle of LBW and to have fewer delivery complications. Maternal height is not only a reflection of genetic make-up, but also reflects her dietary history. Therefore, interventions that would tackle the direct and immediate factors of undernutrition should target not only the ‘window of opportunity’ or the first thousand days (the period between conception and up to 2 years of age), but also the preconceptual period – the adolescent period as part of the life cycle approach [27]. Effective prevention of IUGR/LBW should include improvement of adolescent/maternal nutrition, proper antenatal care, appropriate timely intervention for any obstetric emergency, and etiological management of complications [28]. Balanced protein-energy supplementation of an additional ≥ 700 kcal/day has been found to increase birth weight of newborns of malnourished mothers [29]. Tobacco use is an important modifiable risk factor for preterm/LBW births. Epidemiological evidence shows that tobacco use results in approximately a 70–250 g reduction in birth weight [30]. Domestic violence and stress during pregnancy, common in impoverished households, are believed to be a risk factor for LBW. Appropriate care of LBW infants, including feeding, temperature maintenance, hygienic cord and skin care, and early detection and treatment of complications, can substantially reduce mortality in this highly vulnerable group [24].

Protein-Energy Malnutrition

Protein-energy malnutrition includes a number of distinct disorders of growth in children mostly caused by protein and energy deficiency. All malnourished children are classified as underweight (low body weight compared with healthy peers; weight-for-age Z score < -2),

stunting (poor linear growth; height-for-age Z score < -2), wasting (acute weight loss; weight-for-height Z score < -2) or as edematous malnutrition (kwashiorkor) according to the World Health Organization (WHO) [31].

Directly or indirectly, malnutrition is responsible for 54% of all deaths among children under 5 years of age in developing countries [32]. An estimated one third of under-5 children (178 million) are stunted, whereas 112 million are underweight, making malnutrition the most common ‘disease’ of children. Worldwide, only 36 countries account for 90% of all stunted children [26]. Of the global deaths among under-5 children, 19% are attributed to underweight, 14.5% to stunting, and 14.6% to wasting. India alone has >61 million stunted children (prevalence rate 51%) [26]. Although the prevalence rates of childhood malnutrition are slowly declining in Asia, the highest prevalence can still be found in South Asia.

It is a shame to have such a huge burden of childhood malnutrition. Priority interventions to reduce the burden include:

- *Breastfeeding Promotion.* Early and exclusive breastfeeding is an important intervention of proven efficacy that reduces neonatal, infant, and child mortality, and remains a basis for child survival strategies. As much as 13% of all global deaths of children under 5 years of age can be prevented through breastfeeding promotion [33].

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• *Appropriate Complementary Feeding.* The period from birth to 2 years of age is well recognized as the ‘critical window’ for the promotion of optimal growth, health, and development. Even with optimal breastfeeding, children become stunted if they do not receive sufficient quantities of quality complementary foods after 6 months of age [26]. A global estimate indicated that about 33% of children aged 6–23 months receive optimal complementary feeding [10] in terms of amount, frequency, and consistency of diet.

• *Supplementation with Essential Vitamins and Minerals.* Vitamin A deficiency in newborn babies, infants, and children accounts for about 6% of under-5 deaths, 5% of under-5 DALYs, and 1.7% of total DALYs lost. Zinc deficiency accounts for about 4% of under-5 deaths and DALYs and 1% of total DALYs lost [26]. Vitamin A supplementation can reduce all-cause mortality for children 6–59 months by 23%, and several studies suggest that therapeutic zinc supplements for diarrhea can reduce diarrheal mortality below the age of 5 years by 50% [34]. About 41 million newborns per year remain unprotected from the serious consequences of brain damage associated with iodine deficiency [35] which could easily be prevented by ensuring that salt consumed by household members is adequately iodized.

• *Appropriate Management of Severe Acute Malnutrition.* Application of the WHO protocol for management of severe acute malnutrition (SAM) could reduce the number of deaths by 55% and prevent 152,000 deaths in hospitals or health facilities equivalent to averting 5 million DALYs [36]. To achieve this reduction, all children at high risk of death from SAM would need to reach a health facility capable of delivering the WHO protocol. However, few children with SAM can actually be treated in a hospital setting because of lack of beds, time and cost taken for the travel to a hospital, etc. In countries that have a high burden of acute malnutrition, there should be interventions on community-based management of acute malnutrition (CMAM). Many high-burden countries are yet to have national CMAM programs. An important reason for the reluctance to have national CMAM programs is the need to import ready-to-use therapeutic food (RUTF) and its high cost. Imported RUTF is not considered sustainable in non-emergency settings. A recent Zambian study shows that RUTF alone constitutes 36% of the total cost of CMAM [37]. An effective solution to this problem would be local

production of RUTF. When RUTF is made with locally available food ingredients, it becomes readily available, easily accessible, culturally acceptable, and cost-effective. Research is urgently needed to develop recipes of RUTF conforming to international specifications using locally available food ingredients. CMAM should be tagged with interventions that prevent malnutrition, including food security, livelihood creation, and water-sanitation-hygiene interventions. The impact of such bundling of interventions, however, needs to be evaluated through robust experiments.

• *Sanitation and Hygiene Interventions.* Gastrointestinal infections like diarrhea adversely affect nutritional status, while malnutrition can predispose to infections like diarrhea. About 88% of all cases of diarrhea globally are attributable to unsafe water, poor sanitation and

Worldwide, the four most widespread forms of micronutrient malnutrition are iron, vitamin A, iodine, and zinc deficiencies.

hygiene; such a high rate of diarrhea, along with stunting, can be reduced by sanitation and hygiene interventions [38]. These interventions are also believed to reduce environmental enter-

opathy – a condition caused by chronic exposure to pathogens that colonize the small intestine resulting in villous damage, malabsorption of nutrients, and malnutrition [39].

Micronutrient Deficiencies

Micronutrient malnutrition is rampant in developing countries. Though it can affect any age group, young children and women of reproductive age tend to be among those most at risk. Even moderate levels of deficiency can lead to serious adverse effects on various functions of the body. Worldwide, the four most widespread forms of micronutrient malnutrition are iron, vitamin A, iodine, and zinc deficiencies. According to the WHO World Health Report, almost one third of the world’s population is affected by them, the majority living in developing countries (table 2). It has been estimated that micronutrient deficiencies account for about 7.3% of the global burden of disease, with iron and vitamin A deficiency ranking among the 15 leading causes of the global disease burden [40].

WHO mortality data shows around 0.8 million deaths (1.5% of the total) can be attributed to iron deficiency each year as well as to vitamin A deficiency. In terms of the loss of healthy life, expressed in DALYs, iron deficiency anemia results in 25 million DALYs lost (or 2.4% of the

Table 2. Prevalence of the three major micronutrient deficiencies by WHO region [48–50]

WHO region	Anemia ^a (total population)		Insufficient iodine intake ^b (total population)		Vitamin A deficiency ^c (preschool children)	
	n (millions)	% of total	n (millions)	% of total	n (millions)	% of total
Africa	244	46	260	43	53	49
Americas	141	19	75	10	16	20
South-East Asia	779	57	624	40	127	69
Europe	84	10	436	57	no data available	
Eastern Mediterranean	184	45	229	54	16	22
Western Pacific	598	38	365	24	42	27
Total	2,030	37	1,989	35	254	42

^a Based on the proportion of the population with hemoglobin concentrations below established cutoff levels.

^b Based on the proportion of the population with urinary iodine <100 µg/l.

^c Based on the proportion of the population with clinical eye signs and/or serum retinol ≤0.70 µmol/l.

Table 3. Global deaths and DALYs in children <5 years of age attributed to micronutrient deficiencies [26]

	Deaths	% of deaths in children <5 years	Disease burden (1,000 DALYs)	% of DALYs in children <5 years
Vitamin A deficiency	667,771	6.5	22,668	5.3
Zinc deficiency	453,207	4.4	16,342	3.8
Iron deficiency	20,854	0.2	2,156	0.5
Iodine deficiency	3,619	0.03	2,614	0.6

global total), vitamin A deficiency in 18 million DALYs lost (or 1.8% of the global total), and iodine deficiency in 2.5 million DALYs lost (or 0.2% of the global total) (table 3) [40].

Iron Deficiency Anemia

Iron deficiency is the most prevalent nutritional problem in the world. Out of 2 billion global anemia cases, iron deficiency alone accounts for 50% [41]. The WHO review of nationally representative surveys from 1993 to 2005 shows that 42% of pregnant women and 47% of preschool children worldwide have anemia [26]. The major risk factors are low intake of meat, fish or poultry and high intake of cereals and legumes, LBW, pregnancy, etc. [42]. Anemia is also caused or worsened by infectious diseases such as malaria, HIV/AIDS, hookworm infestation, schistosomiasis, and tuberculosis. The health consequences from iron deficiency range from reduced cognitive performance, lower work performance and endurance, impaired iodine and vitamin

A metabolism to increased risk of maternal and child mortality.

Vitamin A Deficiency

This is another major nutritional concern in poor societies, particularly in lower-income countries. According to worldwide survey data, an estimated 254 million preschool children are vitamin A deficient [41]. Low intake of dairy products, eggs, and fresh fruits and vegetables are the reasons for such deficiency. A meager diet and infection frequently coexist and interact in populations where vitamin A deficiency is prevalent. Vitamin A deficiency can increase the severity of infection which, in turn, can reduce intake and accelerate body losses of vitamin A to aggravate the condition (fig. 3). Xerophthalmia is the leading cause of preventable childhood blindness which is a consequence of long-term or severe vitamin A deficiency [43]. Low vitamin A consumption during nutritionally demanding periods in life, such as infancy, childhood, pregnancy, and lactation, greatly

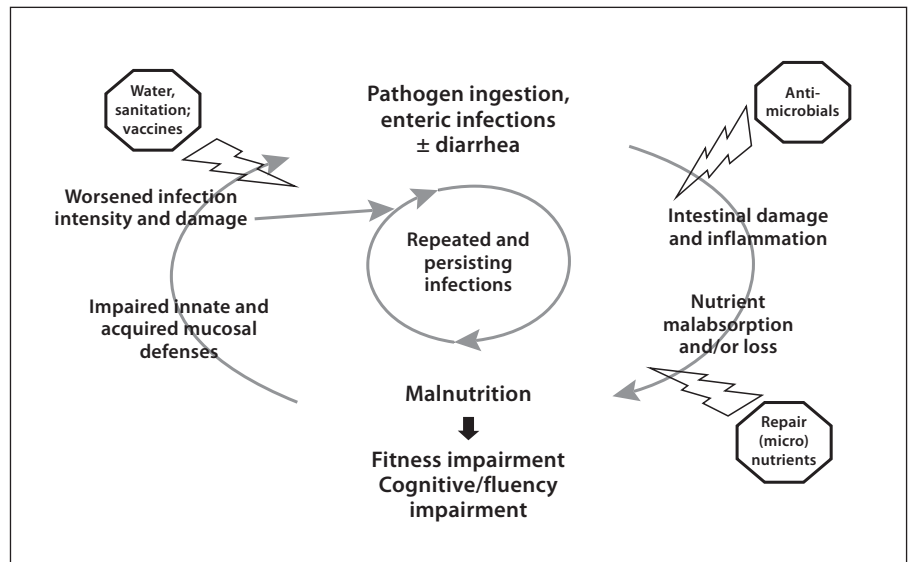


Fig. 3. Vicious cycle of malnutrition and infection [53].

raises the risk of vitamin A deficiency disorders. Using data collected from 1995 to 2005 and using population figures from 2006, the WHO estimated that approximately 5.2 million preschool children and 9.8 million pregnant women are affected by xerophthalmia yearly.

Zinc Deficiency

Definitive data on prevalence of zinc deficiency are insufficient, but it is thought to be moderate to high in developing countries, especially in South Asia, most of sub-Saharan Africa, and the Western Pacific. About 20% of the world's population could be at risk of zinc deficiency [44]. Worldwide, zinc deficiency is responsible for approximately 16% of lower respiratory tract infections, 18% of malaria, 10% of diarrheal disease, and in total 1.4% (0.8 million) of deaths [40]. Zinc is essential to perform functions including healing of wounds, growth and repair of tissue, proper clotting of blood, correct thyroid function, metabolism of proteins, carbohydrates, fats and alcohol, fetal development, and sperm production. Low intake of animal products, high phytate intake, persistent diarrhea and malabsorption, and infection with intestinal parasites are the considered risk factors for zinc deficiency. Zinc deficiency in children results in increased risk of diarrhea, pneumonia, and malaria, as evidenced by many randomized placebo-controlled trials done in various populations in all regions of the world [45]. Severe deficiency results in dermatitis, retarded growth, mental disturbance, delayed sexual maturation, and/or recurrent infections [41].

Iodine Deficiency

Iodine deficiency has adverse effects on both pregnancy outcome and child development. Even deficiency in subclinical level during pregnancy impairs motor and mental development of the fetus and increases risk of miscarriage and fetal growth restriction [26]. It is the most widespread, but easily avertable, cause of brain damage. Over 2.2 billion people in the world may be at risk for iodine deficiency, and current estimates suggest that >1 billion experience some degree of goiter [46]. Land areas with a low level of iodine in soil and water and living in high-altitude regions far from the sea are the risk factors for iodine deficiency. Lack of iodine consumption results in increased risk of stillbirth, infant mortality, impaired cognitive function, hypothyroidism, goiter, etc.

Conclusions

With a substantial segment of the world's population suffering from undernutrition, national governments, international agencies and development partners should work in concert to control IUGR, undernutrition, food insecurity, and micronutrient deficiencies. Only then will human development be possible.

Disclosure Statement

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References

- 1 The Manoff Group: Guidance for Formative Research on Maternal Nutrition. Infant and Young Child Nutrition Project, 2011. <http://www.manoffgroup.com/GuidanceforFormativeResearchonMaternalNutrition.pdf> (accessed September 25, 2012).
- 2 Smith LC, Ramakrishnan U, Ndiaye A, Haddad L, Martorell R: The Importance of Women's Status for Child Nutrition in Developing Countries. Washington, DC, International Food Policy Research Institute, 2003.
- 3 Osmani S, Sen A: The hidden penalties of gender inequality: fetal origins of ill-health. *Econ Hum Biol* 2003;1:105–121.
- 4 National Institute of Population Research and Training (NIPORT), Mitra and Associates (MA), and ORC Macro (ORCM): Bangladesh Demographic and Health Survey 2007. Dhaka, Bangladesh, Calverton, MD, 2007.
- 5 Khan YP, Bhutta SZ, Munim S, Bhutta ZA: Maternal health and survival in Pakistan: issues and options. *J Obstet Gynaecol Can* 2009;31:920–929.
- 6 Atmarita: Nutrition problems in Indonesia; in: An Integrated International Seminar and Workshop on Lifestyle-Related Diseases 2005; Gajah Mada University, 19–20 March, 2005. Directorate of Community Nutrition, Ministry of Health, 2005.
- 7 SCN/ACC: 5th Report on the World Nutrition Situation: Nutrition for Improved Development Outcomes. Geneva, World Health Organization, 2004.
- 8 Bhutta ZA, Gupta I, de'Silva H, et al: Maternal and child health: is South Asia ready for change? *BMJ* 2004;328:816–819.
- 9 Begum S, Sen B: Maternal Health, Child Well-Being and Intergenerationally Transmitted Chronic Poverty: Does Women's Agency Matter? Bangladesh Institute of Development Studies (BIDS), Chronic Poverty Research Centre (CPRC), Institute for Development Policy and Management (IDPM), University of Manchester, 2005.
- 10 Khan Y, Bhutta ZA: Nutritional deficiencies in the developing world: current status and opportunities for intervention. *Pediatr Clin North Am* 2010;57:1409–1441.
- 11 Shannon K, Mahmud Z, Asfia A, Ali M: The social and environmental factors underlying maternal malnutrition in rural Bangladesh: implications for reproductive health and nutrition programs. *Health Care Women Int* 2008;29:826–840.
- 12 Ramachandran M, Kumar KSK, Viswanathan B: Vulnerability to Chronic Energy Deficiency: An Empirical Analysis of Women in Uttar Pradesh, India. Chennai, Madras School of Economics, 2006.
- 13 Bhutta ZA, Ahmed T, Black RE, et al: What works? Interventions for maternal and child undernutrition and survival. *Lancet* 2008;371:417–440.
- 14 SCN News: Tackling the Double Burden of Malnutrition: A Global Agenda. United Kingdom, Standing Committee on Nutrition, 2006.
- 15 Ribeiro PS, Jacobsen KH, Mathers CD, Garcia-Moreno C: Priorities for women's health from the Global Burden of Disease study. *Int J Gynaecol Obstet* 2008;102:82–90.
- 16 Rao S, Gokhale M, Joshi S, Kanade A: Early life undernutrition and adolescent pregnancy outcome in rural India. *Ann Hum Biol* 2010;37:475–487.
- 17 Girma W, Genebo T: Determinants of the Nutritional Status of Mothers and Children in Ethiopia. Calverton, MD, ORC Macro, 2002.
- 18 Kotecha PV, Nirupam S, Karkar PD: Adolescent girls' anaemia control programme, Gujarat, India. *Indian J Med Res* 2009;130:584–589.
- 19 Food and Agriculture Organization: Policy Brief: Food Security. Rome, FAO, 2006.
- 20 World Health Organization, UNICEF: WHO Child Growth Standards and the Identification of Severe Acute Malnutrition in Infants and Children: A Joint Statement by the World Health Organization and the United Nations Children's Fund. Geneva, 2009.
- 21 Victora CG, Adair L, Fall C, et al: Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 2008;371:340–357.
- 22 Andersen LG, Ngquist LA, Eriksson JG, et al: Birth weight, childhood body mass index and risk of coronary heart disease in adults: combined historical cohort studies. *PLoS One* 2010;5:e14126.
- 23 Ojeda NB, Grigore D, Alexander BT: Intrauterine growth restriction: fetal programming of hypertension and kidney disease. *Adv Chronic Kidney Dis* 2008;15:101–106.
- 24 World Health Organization: Guidelines on Optimal Feeding of Low Birth-Weight Infants in Low- and Middle-Income Countries. Geneva, World Health Organization, 2011.
- 25 Jain V, Singhal A: Catch up growth in low birth weight infants: striking a healthy balance. *Rev Endocr Metab Disord* 2012;13:141–147.
- 26 Black RE, Allen LH, Bhutta ZA, et al: Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008;371:243–260.
- 27 Ahmed T, Mahfuz M, Ireen S, et al: Nutrition of children and women in Bangladesh: trends and directions for the future. *J Health Popul Nutr* 2012;30:1–11.
- 28 Maulik D: Management of fetal growth restriction: an evidence-based approach. *Clin Obstet Gynecol* 2006;49:320–334.
- 29 Ahmed AMS, Ahmed T, Mahfuz M, Abdullah K, Cravioto A: Impact of balanced protein-energy supplementation on pregnancy weight gain and birth weight; in Bhutta ZA (ed): *Nutrition Interventions for Maternal and Child Health and Survival*. Karachi, Oxford University Press, 2010.
- 30 Ohlsson DA, Shah DP: IHE Report on Determinants and Prevention of Low Birth Weight: A Synopsis of the Evidence. Alberta, Canada, Institute of Health Economics, 2008.
- 31 World Health Organization: *Physical Status: The Use and Interpretation of Anthropometry*. Geneva, World Health Organization, 1995.
- 32 Schaible UE, Kaufmann SH: Malnutrition and infection: complex mechanisms and global impacts. *PLoS Med* 2007;4:e115.
- 33 Bhutta ZA, Lobbok M: Scaling up breastfeeding in developing countries. *Lancet* 2011;378:378–380.
- 34 Horton S, Begin F, Greig A, Lakshman A: *Micronutrient Supplements for Child Survival (Vitamin A and Zinc)*. Copenhagen Consensus Center, 2008.
- 35 UNICEF: *Tracking Progress on Child and Maternal Nutrition: A Survival and Development Priority*. New York, 2009.
- 36 Bryce J, Coitinho D, Darnton-Hill I, Pelletier D, Pinstrup-Andersen P: Maternal and child undernutrition: effective action at national level. *Lancet* 2008;371:510–526.
- 37 Bachmann MO: Cost effectiveness of community-based therapeutic care for children with severe acute malnutrition in Zambia: decision tree model. *Cost Eff Resour Alloc* 2009;7:2.
- 38 UNICEF: *Evidence Base: Water, Sanitation and Hygiene Interventions: Literature Review*. New York, WASH Section, UNICEF, 2009.
- 39 Kau AL, Ahern PP, Griffin NW, Goodman AL, Gordon JI: Human nutrition, the gut microbiome and the immune system. *Nature* 2011;474:327–336.
- 40 World Health Organization: *The World Health Report 2002 – Reducing Risks, Promoting Healthy Life*. Geneva, World Health Organization, 2002.
- 41 Allen L, Organization WH: *Guidelines on Food Fortification with Micronutrients*. World Health Organization, 2006.
- 42 Bhargava A, Bouis HE, Scrimshaw NS: Dietary intakes and socioeconomic factors are associated with the hemoglobin concentration of Bangladeshi women. *J Nutr* 2001;131:758–764.
- 43 Sommer A: Vitamin A deficiency, child health, and survival. *Nutrition* 1997;13:484–485.

- 44 Global Alliance for Improved Nutrition: Vitamin and Mineral Deficiencies. http://www.gainhealth.org/about-malnutrition/vitamin-and-mineral-deficiencies#footnoteref12_elp9zl1 (accessed August 28, 2012).
- 45 Sazawal S, Black RE, Ramsan M, et al: Effect of zinc supplementation on mortality in children aged 1–48 months: a community-based randomised placebo-controlled trial. *Lancet* 2007;369:927–934.
- 46 Hetzel BS: The Prevention and Control of Iodine Deficiency Disorders. Nutrition Policy Discussion Paper No. 3. ACC/SCN, 1988.
- 47 Fang S: Management of preterm infants with intrauterine growth restriction. *Early Hum Dev* 2005;81:889–900.
- 48 World Health Organization: Iron Deficiency Anaemia: Assessment, Prevention and Control. A Guide for Programme Managers. Geneva, World Health Organization, 2001.
- 49 DeBenoist B, Andersson M, Egli I, Takkouche B, Allen H: Iodine Status Worldwide. WHO Global Database on Iodine Deficiency. Geneva, World Health Organization, 2004.
- 50 World Health Organization, Nutrition Unit, UNICEF: Global Prevalence of Vitamin A Deficiency. Geneva, World Health Organization, 1995.
- 51 World Health Organization: World Health Statistics 2012. Geneva, World Health Organization, 2012.
- 52 ACC/SCN: Low Birthweight: Report of a Meeting in Dhaka, Bangladesh on 14–17 June 1999. Geneva, ACC/SCN in Collaboration with ICDDR,B, 2000.
- 53 Guerrant RL, Oriá RB, Moore SR, Oriá MO, Lima AA: Malnutrition as an enteric infectious disease with long-term effects on child development. *Nutr Rev* 2008;66:487–505.