Postnatal Origins of Undernutrition

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Abstract

Obesity and nutrition-related chronic disorders are fast rising in developing countries. But undernutrition – stunting, underweight, wasting and micronutrient deficiencies – still affect millions of preschool children in both rural and urban settings increasing the risks of morbidity and mortality, impairing cognitive development, reducing productivity and increasing the risk of chronic diseases in later life. In addition undernutrition has a transgenerational effect. Here I review the evidence for a synergistic effect of inadequate nutrition (breastfeeding, complementary feeding), infection, and inappropriate mother–child interactions on growth and nutritional deficiencies. Underlying socioeconomic, environmental and genetic factors are also explored. Finally some perspectives on how urbanization and globalization may affect the prevalence and distribution of undernutrition are discussed. Fighting child undernutrition is still an urgent necessity and a moral imperative.

Introduction

Developing countries are undergoing a rapid nutrition transition characterized by changes in diet and physical activity patterns. These changes are occurring at such a fast rate that the rising burden of obesity and nutrition-related chronic diseases is compounding the secular problems of undernutrition rather than displacing them [1], creating the so-called ‘double burden of malnutrition’. Stunting and overweight have been found to coexist not only at the community level [2] but also within individual households [3] and even within individuals [4]. Moreover, early childhood stunting is now recognized as a risk factor for obesity in later life [4]. Although non-communicable diseases are now the leading cause of death and disability in most developing countries, underweight together with iron, zinc and vitamin A deficiencies are still among the leading 15 causes of death worldwide [5].
The determinants and consequences of childhood undernutrition have been studied for several decades. There is considerable evidence that early nutritional insults are strongly associated with impaired physical growth, increased morbidity and mortality, impaired cognitive development, reduced economic productivity through diminished physical work capacity, increased risk of chronic disease in adulthood and, for women, lower offspring birthweight [6]. Questions remain, however, regarding the precise mechanisms governing malnutrition, such as linear growth faltering [7]. The relationships between proximal and distal factors leading to childhood malnutrition were sketched out nearly 20 years ago in the UNICEF’s classical framework for malnutrition, which is still the reference today [8].

Here I examine how proximal etiological factors for undernutrition, namely inadequate nutrition, infection and maternal–child interactions, can work synergistically to impair child growth. The relative contribution of socioeconomic and demographic factors as well as other environmental factors is also explored. Finally, I discuss how urbanization and globalization may modify the pattern of risk factors.

Effects of Nutrition and Feeding Practices on Infant and Young Child Nutritional Status

Breastfeeding

The WHO recommends breastfeeding exclusively for 6 months and throughout the second year [9]. In Asia and Africa, 75–80% of infants are exclusively or predominantly breastfed for the first 2 months of life [10]. In most women, breast milk provides enough energy and protein to cover the needs of their offspring for normal growth during the first 6 months of life [11]. Wasting or kwashiorkor seldom occur in early infancy and when they do are usually associated with maternal or child inability to breastfeed (famine, maternal physical or mental illness, child cleft lip or cleft palate) in very poor communities.

The worldwide timing of growth faltering (fig. 1) suggests that linear growth retardation starts before 3 months of age and possibly inside the womb [12]. In normal birthweight babies however, weight faltering does not seem to occur until 3–6 months of age [12], suggesting that prenatal influences are more strongly exerted on length than weight accretion. However, caution is in order since antenatal multiple micronutrient supplementation trials have shown a greater effect on birthweight than length [13]. The mechanisms of linear growth retardation are not fully understood, but the timing of initiation of length and weight faltering suggest very different etiologies.

There is empirical evidence for a compounding effect of inadequate breast milk quality coupled with suboptimal infant stores at birth in the etiology of early linear growth faltering. Low birthweight is frequently reported as the
strongest determinant of stunting in the first year of life [14]. In addition, breast milk concentrations of vitamin A, B\textsubscript{6}, and B\textsubscript{12} are strongly influenced by maternal status and diet [11]. Iron, zinc and vitamin D are provided in inappropriate amounts in breast milk regardless of maternal status or intake, and the infant’s needs are met by endowment at birth (or sunlight exposure for vitamin D) until an exogenous source is supplied [11]. It is therefore likely that in deficient populations, infants’ stores at birth together with intake (through breast milk) of several micronutrients fail to meet the requirements for growth and development, contributing to linear growth retardation and micronutrient deficiencies.

**Complementary Feeding: Timing of Initiation**

The attrition rate beyond 2 months for exclusive breastfeeding in Africa and Asia is very important. The proportion of infants exclusively or predominantly breastfed falls to ~50% in the 2–5 months age group indicating that untimely exposure to potentially contaminated or qualitatively inadequate foods is widespread [10]. Introduction of complementary foods increases the risk of diarrhea. Brown et al. [15] in Peru observed a doubling of the prevalence of diarrhea in infants receiving liquids in addition to breast milk compared to those exclusively breastfed. The risk of dehydration from diarrhea was 7 times greater when food was introduced between 3 and 5 months among Brazilian

![Graph showing worldwide timing of growth faltering](image-url)
infants [16]. Early introduction of complementary foods has also been consistently associated with an increased incidence of respiratory illnesses [16].

The introduction of complementary foods displaces breast milk intakes [17]. Although infants are able to self-regulate their energy intake, they are constrained by a small gastric capacity. In addition, the low energy density of mostly plant-based infant porridges in developing countries contributes to a reduction in energy and other nutrient intakes due to their poor availability and bioavailability compared to that in breast milk [17]. Although the availability of micronutrients in human milk can be low, they are generally well absorbed.

Early introduction of complementary foods affects growth directly by reducing the quality and quantity of the diet, and indirectly through increased incidence of diarrheal and other diseases.

**Dietary Quality versus Quantity of Complementary Foods**

From 6 months, breast milk alone is no longer sufficient to meet the requirements for normal biological functions and growth in increasingly active and mobile infants [9]. Most cultures introduce complementary foods in the second half of infancy (e.g., solid family food) and in environments with poor water quality and traditionally low nutrient density diets, infants are at increased risk of nutritional deficiencies [18], in particular moderate and severe acute malnutrition (severe wasting, kwashiorkor) and stunting. It is during this period that growth trajectories deviate markedly from the reference in developing countries. On a global scale, weight-for-age and weight-for-length falter sharply between 3 and 12 months with a some catch-up thereafter, particularly in terms of weight-for-length, more pronounced in Africa. Length-for-age continues to falter throughout infancy and childhood until about 3 years [12].

The initial attention of the research community focused primarily on the influence of weaning on severe acute malnutrition, since the short-term prognosis is highly unfavorable if left untreated. The debate has shifted from protein deficiency, initially hypothesized by Williams [19] in the etiology of kwashiorkor, to energy deficiency. More recently the focus has shifted to multiple deficiencies due to the reduced availability and bioavailability of nutrients in complementary foods [18].

In most developing countries infant porridges are plant-based with a low proportion of energy provided from animal sources [20]. Consequently the bioavailability of nutrients and energy density are reduced and these foods often fail to meet the increasing needs for growth, physical activity, and health. There is strong evidence that wasting, but not stunting, is associated with an energy-deficient diet or one with a low protein to energy ratio [21]. This can be observed at its extreme in anorexic children suffering severe infections, or in times of famine. There is, however, evidence of stunting in children from deprived communities with appropriate energy intakes [22]; Mexican children with energy and protein intakes comparable to those of North American infants
displayed a marked prevalence of stunting, suggesting that other nutrients may be limiting [23]. In the Huascar longitudinal study in Peru, the diet of infants in the second semester averaged 70–75% of energy requirements [18]. Brown [18] calculated that even if these infants would eat larger quantities to satisfy their energy requirements, their diet would remain below the recommendations for protein, vitamin A, calcium, iron, and zinc intakes most of the time. Recently, a review of growth-limiting nutrient intakes from complementary feeding in Bangladesh, Ghana, Guatemala, Mexico, Peru, and the USA revealed that although protein density is adequate, iron, zinc and calcium fail to meet desired intakes across all countries and age groups from 6 to 11 months, and in all countries but the USA between 12 and 23 months [17]. In the 1998 WHO report on complementary feeding, iron and zinc were identified as ‘problem nutrients’ [20]. The bioavailability of zinc and iron is further affected by high concentrations of anti-nutrients (phytates, dietary fibers) in cereal-based preparations as observed in Malawi with maize-based porridges [24].

Poor nutrient quality and quantity in complementary food has an indirect effect on appetite. Growth-retarded Mexican children left over 25% of the food offered suggesting a qualitative rather than a quantitative problem [25]. Several nutritional factors drive appetite in children including the organoleptic properties and viscosity of the food offered [18], but also micronutrient composition. This has been suggested by Golden and Golden [26] who refer to the fact that anorexia is a key feature of zinc deficiency in experimental human and animal studies.

**Infections and Growth**

*Effect of Common Childhood Illnesses on Growth*

There is a clear association between infection and growth faltering. Diarrhea is the most strongly related illness but other acute infections such as pneumonia, malaria, acute febrile illnesses and measles, as well as chronic infections, can impact on growth even at a subclinical stage.

Diarrheal diseases are the most prevalent illnesses in infancy and childhood. Peak incidence occurs in the second half of infancy, coinciding with the introduction of complementary foods and the period when weight faltering is most acute [27]. Diarrheal episodes seem to have a transient effect on weight gain. In studies compiled by Bhan et al. [28], reporting a significant growth impairment due to diarrheal diseases, 8–80% of the short-term weight deficit was explained by diarrhea. The proportion explained was greater in African studies as well as in the context of higher diarrhea prevalence. Long-term effects (beyond 6 months intervals) were somewhat smaller ranging from 6 to 24% of the weight deficit associated with diarrhea, suggesting some catch-up growth. The impact of diarrhea on length velocity was smaller: only 8–15% of the length deficit across nine studies was explained by this type of infection [28].
Lower respiratory tract infections have been associated with a 6–35% deficit in short-term weight gain but no long-term effects beyond 6 months apart from a small effect of severe pneumonia in Brazilian infants [29]. No effect has been reported on length. Malaria and measles have also been reported to have a significant effect on weight [28]. Measles epidemics in very low income countries are frequently associated with subsequent peak admissions of severely malnourished children in rehabilitation centers.

Chronic infections have also been investigated in relation to growth and show different patterns of interaction. Guinean infants infected by Cryptosporidium parvum, a protozoan that causes severe and persistent diarrhea, suffered permanent retardation in both weight and length growth [30]. In The Gambia, colonization of the gastrointestinal tract by Helicobacter pylori in the first half of infancy was significantly associated with shorter, thinner and lighter infants in later infancy [31]. HIV, even subclinical, has been shown to impair linear growth from the first trimester of life and throughout infancy and childhood [32]. It has also been associated with wasting in developing countries but not developed countries, highlighting the importance of appropriate nutritional support [28].

Albendazole trials conducted to investigate the impact of helminthiasis on growth reported inconsistent effects on weight gain, with greater effects in areas of high prevalence. No significant impact on length gain was observed; however, all but one trial was conducted in school-age children where changes in length are unlikely [28].

The variability in the measured effect of various infections as well as the mechanisms by which infections act on weight and length accretion are not fully understood. Effects are greater in high prevalence settings as well as in nutritionally compromised children. Clearly the severity, duration, frequency, and type of infection are key factors mediating the effect on growth by increasing nutrient requirements, losses, and provoking anorexia. Enteropathies affect gut mucosal integrity hence reducing nutrient absorption. In The Gambia, long-term intestinal lesions explain 43% of growth faltering among 2- to 15-month-old children [33].

Synergism of Malnutrition and Infections

The potentiating effect of malnutrition on infection has been recognized for years. Inappropriate dietary energy and micronutrient intake increases susceptibility to and delays recovery from infection. Infection in turn increases the nutrient requirements necessary to contain and combat pathological assaults. Furthermore, infection increases losses (diarrhea) and reduces intakes by affecting appetite, therefore further compromising nutritional status, delaying recovery, and impairing growth [34].

New estimates on the role of undernutrition as an underlying cause of child deaths from infectious diseases were given in the Lancet series on Maternal and Child Undernutrition [10]. Underweight was implicated in 19% of all
deaths, stunting and wasting in approximately 15%, and vitamin A deficiency in 6.5%. Caution is in order when interpreting these figures since the combined effect of multiple deficiencies is less than the crude sum of individual deficiencies as some deaths may be attributable to multiple deficiencies.

**Mother–Child Interactions**

UNICEF first promoted the importance of maternal care in its 1990 conceptual framework for malnutrition to explain differences in nutritional outcomes between communities and households with comparable resources [8].

The level of care provided to infants and children is the result of maternal endogenous factors and societal values, constraints, and policies interacting with each other. Maternal factors determining the quality of the mother–child relationship comprise education and beliefs, physical and mental health, nutritional status and self-confidence. At the interface between maternal and societal determinants are workload and time available for care, and time spent on care, and maternal autonomy and control of resources, highlighting the pivotal influence of the father on the mother–child relationship. Finally the provision of care to children is influenced by the level of social support received by mothers. It is not possible here to review the evidence available for the effect of each of these determinants on the care and feeding practices and ultimately on the child's nutritional status. Instead, I will highlight key findings related to two aspects: maternal education and maternal mental health. For a complete review one can refer to the excellent report by Engle et al. [35].

**Maternal Education**

Children born of women with higher schooling status are less likely to be malnourished. The results of a very large cross-sectional study in Indonesia and Bangladesh recently published in the *Lancet* estimated that each additional year of maternal education decreases the odds of stunting by 4–5% in their offspring [36]. Parental education impacts on child health and nutritional status through three behavioral mechanisms, namely feeding practices, home health practices, and child–caregiver interaction [35].

Maternal education has been associated with a greater commitment to care. In Mexico, mothers from higher education levels were more vocal, had a more stimulating style of interaction with their infant, and were more likely to adapt responsive practices to the age of their infant [37].

Educated mothers adopt better home healthcare provision behaviors in the form of preventative healthcare (immunization, use of antenatal care) and health-seeking behavior for curative medicine. In Metro Cebu, the Philippines, the odds of full immunization of infants rose by 10–15% for each additional year of maternal education [38].
The interaction between feeding practices and maternal education is complex. In Pakistan, the timing of introduction of complementary foods was associated with maternal education [39]. In a study in Bangladesh, maternal education correlated positively not only with feeding frequency and duration, but also with the quality of feeding (less distraction while feeding, cleaner environment, fresher foods, etc.) [40]. In contrast, higher maternal education is consistently associated with earlier termination of breastfeeding in developing countries [35], possibly because better educated mothers engage more in income-generating activities, have less time to dedicate to caring and have wider access to breast milk substitutes due to higher incomes.

Maternal Mental Health

A recent *Lancet* series on mental health highlighted the burden of postnatal depression in developing countries [41]. Postnatal depression affects 10–15% of mothers in developed countries and the proportion is probably higher in low and middle-income countries. Prevalences of 23 and 20% have been reported in India, and 28% in Pakistan [42]. Consistent associations between postnatal mental disorders, child undernutrition and diarrheal episodes have been reported. Infants of antenatally depressed mothers were around 4 times more likely to be underweight and stunted at 6 months and around 2.5 times at 12 months [43]. The risk of having 5 or more diarrheal episodes per year was 2.4.

There is compelling evidence from both developed and developing countries that postnatal depression correlates with long-term cognitive and behavioral problems in children, and failure to thrive [42]. Three mechanisms have been proposed. First, maternal depression is associated with inappropriate healthcare seeking behaviors (full immunization, antenatal care attendance) [43], suboptimal breastfeeding practices and risk-taking behaviors (smoking, drinking alcohol, unhealthy eating) [41, 42]. Second, depressive symptoms impact negatively on the emotional quality of parenting. Depressed mothers provide less quantity and poorer quality of stimulations and are less responsive to their child. Third, maternal depression could increase psychosocial adversity in infancy, which has been linked with stunting [42].

Socioeconomic and Demographic Factors

*Socioeconomic*

Malnutrition is a disease of poverty. Socioeconomic status expressed at the household level (income, expenditure, asset ownership, etc.) has been consistently associated with indices of malnutrition in a variety of studies, but the pathways and mechanisms by which it impacts on child nutritional status are complex, numerous, and highly variable between household, communities and countries. Analysis of the global determinants of stunting and wasting
by Frongillo et al. [44] have highlighted the fact that child undernutrition is as much a consequence of factors at national and provincial levels as at the individual household level. In their model, three quarters of the variability of stunting between countries and two thirds of that of wasting were explained by factors at national and provincial levels. Stunting was more strongly associated with lower energy availability, lower female literacy rates and lower gross domestic product. Wasting was negatively correlated with vaccination coverage and, in Asia, energy availability.

The relationship between poverty and undernutrition at the country level is not linear. For instance Zimbabwe and Kenya have achieved lower rates of underweight and stunting than India, although their gross national income per head is much lower. Mexico has a higher prevalence of stunting than China despite being nearly 4 times more wealthy [45]. The Green Revolution and sustained economic growth in Asia over the past decades contributed to the eradication of famines and brought self-sufficiency in many countries. But in countries like India, mild to moderate undernutrition remain staggeringly high probably due to large inequities in income distribution. Conversely, countries like Panama and Costa Rica have seen a steady decrease in child undernutrition from 1970 to 2000 despite economic stagnation [46].

Other socioeconomic factors associated with child undernutrition in various contexts include: access to safe water (through the incidence and duration of diarrheal diseases); access to healthcare (incidence and duration of infections); dwelling characteristics (wealth, indoor air pollution, etc.); access to latrines (incidence of diarrheal and other diseases due to fecal contamination), and many more.

**Demographic Factors**

The word ‘kwashiorkor’ used by Cecily Williams in her seminal 1933 article was borrowed from the Ga language to designate the disease of ‘the displaced child’ [21] since kwashiorkor was more frequently observed in weanlings experiencing a sudden decline in maternal care and attention due to the arrival of a new sibling. Parity, birth spacing and birth order are among factors frequently associated with child undernutrition. In Thailand, Indonesia and the Philippines, these as well as mortality of the previous child were risk factors for child mortality [47]. Parental marital status and maternal age also seem to exert an influence on child nutritional status. Demographic factors may be partly mediated through socioeconomic status and education.

**Environmental, Genetic and Other Factors**

**Sex**

A higher prevalence of stunting has been reported in boys in several African studies showing a ~15% difference in the prevalence between boys
and girls and a 1.5- to 2-fold increase in the risk of stunting for boys [14, 48]. In a meta-analysis of 16 demographic and health surveys conducted in sub-Saharan African countries, Wamani et al. [49] concluded that the odds of stunting were 18% higher in boys than girls, suggesting that males are more vulnerable to health inequities.

No data were compiled for Asia or Latin America but studies in Bangladesh consistently report higher rates of stunting in girls than boys [50].

**Intergenerational Effect on Undernutrition**

The typical intergenerational cycle of growth failure was described in UNICEF’s State of the World Children 1998: ‘young girls who grow poorly become stunted women and are more likely to give birth to low-birth-weight babies. If those are girls, they are likely to continue the cycle by being stunted in adulthood and so on …’ [8]. Ramakrishnan et al. [51] reviewed the evidence from developed countries and reported on new data from Guatemala. Correlation coefficients of 0.42–0.5 between adult height of parents and their offspring were reported in developed countries. For each 100-gram increase in maternal birthweight, a 10- to 20-gram increase was reported in their offspring. In Guatemala, the increase in child’s birthweight was nearly twice as much (29 g/100 g maternal birthweight) and birth length was increased by 0.2 cm/1 cm increase in maternal birth length. These findings highlight the importance of addressing undernutrition now for future generations but also that it may take several generations to completely eradicate stunting.

**Seasonality, Food Availability and Infections**

Seasonal variations in growth patterns among agro-pastoral communities have been described in many countries, with weight showing greater seasonal variability than height. The nadir of weight faltering has been correlated with the timing of lowest food availability (pre-harvest period) in Bangladesh and Kenya [50, 52] or the period of highest diarrhea incidence in Uganda and Bangladesh [50, 53]. Resumption of height growth seems to lag 3–4 months behind that of weight accretion in line with Golden’s [54] observation that during catch-up growth (recovery from severe acute malnutrition) weight takes precedence over length.

**Perspective on Urbanization, Globalization and Undernutrition**

The United Nations’ Population Division estimates that in 2008 the proportion of the urban population will equal the rural population and be urbanized in its majority thereafter [55]. These changes have taken place increasingly rapidly in the last two decades in the context of the globalization of trade, technology, information, and labor resources.
Over a third of the urban population in the developing world live in shanty towns and are exposed to a lack of access to safe water, poor housing conditions, overcrowding, poor hygiene conditions due to lack of drainage, and environmental pollution. Consequently, children are exposed to higher transmission rates of respiratory and diarrheal diseases than in rural areas [56]. Urbanization affects not only the environment but behaviors. Rates and duration of breastfeeding are lower in urban than rural areas in Africa and Latin America [57], and the ability and, often, the necessity of mothers to work impacts on the time and quality of health and nutrition care. It is not surprising that children from urban slums in India have a higher prevalence of underweight, stunting and wasting than those living in rural areas [58].

A feature of trade globalization has been a sustained integration of national markets to the global economy. For poor, often urban populations in developing countries, this has meant greater stability in food availability thus a better resilience against adverse local climatic and man-made disasters, but also a greater vulnerability to global price fluctuations. The price of oil and basic food commodities is rising rapidly nowadays, pulled by a booming demand from China and diversion of agricultural productions into biofuel generation reducing global food availability and accessibility. Riots erupted recently in Cameroon (February 2008), Burma (July 2007), and Iran (June 2007) over the price of oil. In China, a harsh winter characterized by gigantic floods has meant a sharp increase in basic food products and a steep decline in rice exports, affecting global prices. Whether or not this may signal the return of famines in Asia and elsewhere is unknown, but low income countries already suffering a disproportionate share of the burden are ill equipped to face a global competition for dwindling resources.

**Conclusion**

The increasing prevalence of obesity and nutrition-related chronic disease compounds rather than displaces traditional health problems due to undernutrition in developing countries. Trends indicate that, if left unchecked, stunting will remain the most prevalent nutritional disorder in childhood, and underweight, wasting and micronutrient deficiencies will continue to affect children throughout their lives and across generations. The burden of child undernutrition remains so great that there is a renewed moral urgency to find integrated solutions to tackle the problem. Over- and undernutrition are now seen as different manifestations of a global phenomenon rather than extremes of the malnutrition spectrum. Since they are linked, fighting undernutrition should impact positively on both outcomes.
References


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54 Golden MHN: The role of individual nutrient deficiencies in growth retardation of children as exemplified by zinc and protein; in Waterlow JC (ed): Linear Growth Retardation in Less...

Discussion

Dr. Haschke: My comment is related to the growth curves which you showed. You are still using the NCHS growth curves as the reference. Since the arrival of the WHO growth curves, we know that the NCHS references are completely outdated because they overestimate weight and length during the second 6 months of life. Therefore if the NCHS curves indicate that disabled populations have a z score of –1.25 for weight for age, the new WHO curves would indicate a z score of between –0.6 or 0.7. This would be less dramatic. The new WHO growth curves provide a much better estimate of the growth of infants who are breastfed according to the present recommendations. A second short comment: you showed the growth of infants with HIV until 22 years; I assume it is 22 months.

Dr. Prost: The graph showing the growth of children according to their HIV status is over the 2 first years of life, so it is 22 months. Coming back to your comment about the WHO growth standards, I completely agree with you but with caution because the implications of the new WHO standards are not fully understood with regard to how they compare with the NCHS references that were widely used until then. In very early infancy using the WHO growth standards will increase the prevalence of stunting, wasting and underweight, and in later infancy, in childhood, it is likely to be fairly similar to the NCHS references. In my opinion the issue of using the new WHO standards and how they will impact on our estimation of undernutrition has not yet been sorted out.

Dr. Haschke: The differences between the 2 growth curves are substantial. During the first 3 months the new WHO growth curves show exactly the same pattern you showed in breastfed infants, weight and length are above the NCHS. However, from 4 to 12 months the new WHO standards for weight and length are 0.6 z scores lower than indicated by the NCHS references.

Dr. Pandit: You mentioned iron, zinc and vitamin A deficiencies among the leading causes of death. How is the cause-and-effect relationship established between the iron, zinc and vitamin A deficiencies? What indicators have been used?

Dr. Prost: The data I have presented were from the World Health Report 2002, so these are WHO estimates and I am not aware of how they calculated these.

Dr. Christian: I think the vitamin A estimates are based on randomized placebo-controlled trials of vitamin A supplementation in young children and their impact on child mortality. With zinc what they have done for the recent estimate in the Lancet series [1] is to use the two trials of zinc supplementation also using a placebo-controlled randomized study design to estimate the relative contribution of zinc deficiency to childhood mortality. With regard to iron, I think those estimates are based on two randomized control trials of iron supplementation but actually in the malarious setting they have shown a negative impact of iron on morbidity and mortality.
**Dr. Ganapathy:** The Nepal study [2] which involved about 65,000 children has given zinc a questionable role. Are we dealing more with food faddism which is contributing to zinc and iron deficiencies or are we overestimating the problem? Is there a role for zinc?

**Dr. Christian:** The question about whether zinc plays a role is related to using or promoting zinc supplementation to prevent childhood mortality. A program would actually have to be developed that targets all children of that age group for daily zinc supplementation, and it is questionable whether that is really possible given the modest effects on mortality that were observed in that study.

**Dr. Shetty:** I completely agree with Dr. Haschke that the numbers of undernourished, all categories, are going to change, particularly stunting and underweight, because the new WHO standards have produced growth references for children which are based on data from exclusively breastfed children from developing countries and India is part of this database. With the changes in both bodyweight and length, the numbers and prevalence of stunting and underweight will change [3]. The second point I want to make is with regard to your comments on the rise in food prices. There is no doubt that there has been an increase in food prices over the last 12 months or so, largely because of the increased food being diverted to feed animals (a lot of soya production in Brazil goes straight to China to feed animals), and also maize for instance going to biofuel production in the USA. But if you look at the changes in food prices over the last 20 years there has been a remarkable drop in food prices that what we are paying now for food does not even cover the production costs of that food. So this increase since 1980 is a very small increase in food price. I know it will affect a lot of low income people but the same low income people have benefited from extremely low food prices over the last 20 years. We may hence be misleading when we state that the cause of undernutrition in children is because of the increase in food prices over the last 12 months.

**Dr. Prost:** I completely agree with you, this is a very short period of time to look at an increase in food prices, but if we look at the larger picture, the conclusion might be a little bit different. However, I think that over a very short period of time there has been a substantial increase, but nobody here can say whether it really has increased child undernutrition or not because we don’t have the data. Obviously when there is a 50% increase in food prices, it will very strongly affect the poor. We might not be affected as much by that, but the poor will certainly feel it, and I think it is linked to the price of oil as well. As you said, we have a short view here on food prices, and all the prices are increasing and nobody would actually dare to say that they are going to decrease. In the long-term food prices will continue to increase, and if they continue to increase at the present rate there will be a problem, there is no doubt about it.

**Dr. Shetty:** If you look at undernutrition in Indonesia, for instance, you can see how the economic crisis in East Asia has had an impact on undernutrition. So when you talk about global factors, food is just one component. If there is an economic recession, even if food prices do not change because they are subsidized, there will still be an impact on child undernutrition, and therefore to highlight just the rise in food prices as being the main causative driver of undernutrition is something that I do not agree with.

**Dr. Sirajul Islam:** As far as the food price is concerned, I think the food prices have risen very alarmingly. Two years back the price of rice was 21 taka/kg and it is now more than 50 taka/kg, pulses were 30 taka/kg, now they are 140 taka/kg, and this has happened in the last couple of months. For a man who earns 150 taka/day, has a family of 5 children and isn’t working regularly, it is a devastating situation. We must not underestimate the food price at the present time.
Dr. Wharton: Can I ask you to enlarge a bit on your views on the effects of urbanization? The current ideas are that urbanization in developing countries generally isn’t good, and yet historically in other communities urbanization is being associated with a reduction in mortality rates, with employment, and easier access to sources of education, and so on. Could you just say a bit more about what you think about urbanization?

Dr. Prost: The first thing I should highlight is that my field is epidemiology, so I am not very knowledgeable about the effect of urbanization on child undernutrition. Dr. Popkin could answer that question better than me. Urbanization as such is not a problem, it is uncontrolled urbanization. Urbanization is associated generally with an increase in income and that has a positive effect on child undernutrition. But uncontrolled urbanization leads to an increased exposure to risk, particularly for children, and this is what I wanted to highlight in my talk, the extent to which it has a negative impact on the health of children.

Dr. Agarwal: I have only two comments to make. One is in the case of India. Undernutrition has remained the same, wasting as well as stunting, for the last 7 years, and therefore this marginal rise in prices has not had an affect. The second thing I have seen in rural areas where I have done some interventions is that the weaning food is contaminated, the bottles, the utensils and the water are all contaminated. We have to solve two problems: one is water control and the other is bringing down the bacterial content of the water, and the cleaning of things. In dealing with infections, such as diarrhea and respiratory infections, it should be taken into account that the weaning foods are contaminated. I think the Gambian experience also shows the same.

Dr. Matthai: You made the point that there is still a very high burden of malnutrition in India. I think it is important to remember that what we now see in most parts of India is not the severe malnutrition that we used to see about 20 years ago. Most of what we see is the milder grades – grades 1 or 2. I suspect if we apply the new WHO standards and growth curves many of those who we have been classified as having malnutrition by our earlier standards would now be classified as normal. So, yes, there still is malnutrition in India, but I think the prevalence and severity are probably much less than what is commonly thought.

Dr. Christian: I just wanted to point out that both the NFHS-3 and the Lancet series’ estimates of the global burden of undernutrition have used the new standards and rates that we were discussing earlier on, the 51% of stunting is based on using the new standards, so I don’t think that we are misclassifying malnutrition, that is not really happening.

References