Interventions to Address Maternal and Childhood Undernutrition: Current Evidence

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Abstract
The global burden of undernutrition remains high with little evidence of change in many countries. We reviewed the evidence of the potential nutritional interventions and estimated their effect on nutrition-related outcomes of women and children. Among the maternal interventions, daily iron supplementation results in a 69% reduction in incidence of anemia, 20% in incidence of low birthweight (LBW) and improves mean birthweight. MMN supplementation during pregnancy has been shown to significantly decrease the number of LBW infants by 14% and small for gestational age (SGA) by 13%. Balanced protein-energy supplementation reduces the incidence of SGA by 32% and risk of stillbirths by 38%. Antimalarials when given to pregnant women increase the mean birthweight significantly and were associated with a 43% reduction in LBW and severe antenatal anemia by 38%. Among the neonatal and child interventions, educational/counseling interventions increased exclusive breastfeeding by 43% at 4–6 weeks and 137% at 6 months. Vitamin A supplementation (VAS) reduces all-cause mortality by 24% and results in a 14% reduction in the risk of infant mortality at 6 months. Intermittent iron supplementation in children reduces the risk of anemia by 49% and iron deficiency by 76%, and significantly improves hemoglobin and ferritin concentration. Preventive zinc supplementation in populations at risk of zinc deficiency decreases morbidity from childhood diarrhea and acute lower respiratory infections, and increases linear growth and weight gain among infants and young children. Among the supportive interventions, hand washing with soap significantly reduces diarrhea morbidity by 48%, though it depends on access to water. The effect of water treatment on diarrhea morbidity also appears similarly large with a 17% reduction. Recent research has established linkages of preconception interventions with improved maternal, perinatal and neonatal health outcomes, and it has been suggested that several proven interventions recommended dur-
ing pregnancy may be even more effective if implemented before conception. These proven interventions, if scaled up have the potential to reduce the global burden of undernutrition substantially.

Introduction

The State of Food Insecurity estimates that around 870 million people globally have been undernourished (in terms of dietary energy supply) in the period 2010–2012 [1]. The vast majority of these, 852 million, live in developing countries, where the prevalence of undernourishment is around 14.9% [1]. Though many countries are on track in reducing income poverty [Millennium Developmental Goal (MDG) 1a], less than a quarter of developing countries are on track to achieve the goal, of halving undernutrition (MDG 1c) by the year 2015. The global burden of undernutrition remains high with little evidence of change in many countries despite economic growth, and still millions of people are faced with starvation and malnutrition, with women and children contributing the major share. The progress has also been hampered by the global increase in food and oil prices, climate change, unprecedented draughts and increased number of countries affected by fragility, conflict and emergencies. According to the World Bank, 33 countries fall in the fragile situations category and, in addition, conflict and fragility also occur at the sub-national level within some strongly performing countries. The World Bank further estimated that the food price crisis in 2008 pushed as many as 130–155 million more people globally into extreme poverty with an increase in the number of children suffering permanent cognitive and physical injury due to malnutrition by 44 million.

Malnutrition, including micronutrient deficiencies, remains one of the major public health challenges, particularly in developing countries [2]. Poor maternal nutrition contributes to at least 20% of maternal deaths, and increases the probability of other poor pregnancy outcomes including newborn deaths [2]. Low body mass index among women of reproductive age is an important risk factor for intrauterine growth restriction, low birthweight (LBW) and neonatal mortality. Other maternal indicators for poor pregnancy and neonatal outcomes include low maternal stature, anemia and other micronutrient deficiencies.

In the year 2011, almost 6.9 million children under 5 years of age died worldwide [3], and undernutrition was an underlying cause in about one third of these deaths which included stunting, severe wasting, deficiencies of vitamin A and zinc, and suboptimal breastfeeding. Globally, around 165 million children under 5 suffer from stunting, 101 million are underweight and 52 million are wast-
ed, and approximately 90% of these live in just 36 countries with the highest prevalence in Southeast Asia and Sub-Saharan Africa [4] (fig. 1). Prevalence of malnourished children has decreased, and progress has been made in the past two decades, but at the current rate of progress, United Nations regional goals are unlikely to be met in all developing countries, and micronutrient deficiencies remain widespread among women and children globally.

Fig. 1. Latest country prevalence estimates for stunting among children under 5 years of age. Source: http://www.who.int/nutgrowthdb/jme_unicef_who_wb.pdf.

To address this persistent burden of undernutrition in women and children and to the population at large, various strategies have been employed worldwide. Among these are nutrition education, dietary modification, food provision/supplementation, agricultural interventions including bio-fortification, micronutrient supplementation and fortification. Apart from these direct nutritional interventions, programs to tackle the underlying causes of undernutrition including prevention and management of infections (like diarrhea and malaria) have also been initiated and implemented at various levels of care. Parallel programs have also been pursued to increase coverage and aid uptake of these primary interventions including provision of financial incentives at various levels, home gardening and community-based nutrition education and mobilization programs. Although all these strategies have shown success and proved to be effective, a coherent, multifaceted and integrated action which has the global consensus is lacking, and several attempts at developing consensus is fraught with con-
troversies and lack of coordination between various academic groups and development agencies.

Concerns for these deprived prospects have called for improved efforts to speed up and scale up the implementation of effective interventions in a systematic manner to achieve high and equitable coverage of interventions. In the following sections, we will review various interventions (table 1) and their evidence-based proven effectiveness.

**Review of Interventions**

**Micronutrient Supplementation**

The World Health Organization (WHO) estimates that in spite of recent efforts in the prevention and control of micronutrient deficiencies, over two billion people are at risk for vitamin A, iodine, and/or iron deficiency globally [5]. Other micronutrient deficiencies of public health concern include zinc, folate, and the B vitamins. In many settings, more than one micronutrient deficiency coexists, suggesting the need for simple approaches that evaluate and address multiple micronutrient (MMN) malnutrition [6]. Micronutrient supplementation is the most widely practiced intervention to prevent and manage single or MMN deficiencies. Various programs are in place to address these micronutrient deficiencies through supplementation, and evidence from evidence-based systematic reviews suggests that among pregnant women, daily iron supplementation is associated with a 69% reduction in incidence of anemia at term, 66% reduction in iron deficiency anemia at term, 20% reduction in incidence of LBW and improved birthweight [7]. Calcium supplementation during pregnancy is associated with a 52% reduction in the incidence of preeclampsia and 24% reduction in preterm birth with an increase in birthweight of 85 g, while no significant impacts were observed on perinatal mortality [8]. MMN supplementation during pregnancy significantly reduces the incidence of LBW infants by 11% and small for gestational age (SGA) by 13%. When compared with iron and folate supplementation while the impact on preterm birth, miscarriage, preeclampsia, maternal mortality, perinatal mortality, stillbirth and neonatal mortality was statistically not different [9]. Evidence of micronutrient supplementation in children indicates that vitamin A supplementation (VAS) reduces all-cause mortality and diarrhea-specific mortality by 24% and 28%, respectively [10]. VAS also reduces the incidence of diarrhea by 15% and measles morbidity by 50%; however, there was no significant effect on the incidence of respiratory disease. Iron supplementation in children results in a 49%
Table 1. Interventions to improve maternal and child undernutrition and estimates

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Estimates</th>
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<tr>
<td><strong>Maternal interventions</strong></td>
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<tr>
<td>Iron/iron-folate supplementation</td>
<td>LBW (RR: 0.80, 95% CI: 0.68–0.97), birthweight (mean difference, MD: 30.81 g, 95% CI: 5.94–55.68), serum hemoglobin concentration at term (MD: 8.88 g/l, 95% CI: 6.96–10.80), anemia at term (RR: 0.31, 95% CI: 0.19–0.46), iron deficiency (RR: 0.43, 95% CI: 0.27–0.66), iron deficiency anemia (RR: 0.34, 95% CI: 0.16–0.69), side effects (RR: 2.36, 95% CI: 0.96–5.82), while nonsignificant impacts on premature delivery, neonatal death, congenital anomalies.</td>
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<td>Maternal calcium supplementation</td>
<td>52% reduction in the incidence of preeclampsia (RR: 0.48, 95% CI: 0.34–0.67) with an increase in birthweight of 85 g. 24% reduction in risk of preterm birth (RR: 0.76, 95% CI: 0.60–0.97), while nonsignificant impacts on perinatal mortality, LBW and neonatal mortality.</td>
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<td>Maternal multiple micronutrient</td>
<td>LBW (RR: 0.89, 95% CI: 0.83–0.94) and SGA (RR: 0.87, 95% CI: 0.81–0.95), while nonsignificant impacts on preterm birth, miscarriage, maternal mortality, perinatal mortality, stillbirths and neonatal mortality.</td>
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<tr>
<td>supplementation</td>
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<td>Maternal BEP supplementation</td>
<td>Reduction of 34% (RR: 0.66, 95% CI: 0.49–0.89) in the risk of SGA infants and 38% in stillbirths (RR: 0.62, 95% CI: 0.40–0.98). It also increased birthweight (MD: 73 g, 95% CI: 30–117).</td>
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<tr>
<td><strong>Child interventions</strong></td>
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<td>Iron supplementation</td>
<td>Anemia (RR: 0.51, 95% CI: 0.37–0.72), iron deficiency (RR: 0.24, 95% CI: 0.06–0.91), hemoglobin (MD: 5.20 g/l, 95% CI: 2.51–7.88), ferritin (MD: 14.17 μg/l, 95% CI: 3.53–24.81).</td>
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<td>Vitamin A supplementation</td>
<td>All-cause mortality reduced by 24% (RR: 0.76, 95% CI: 0.69–0.83), diarrhea-related mortality by 28% (RR: 0.72, 95% CI: 0.57–0.91), incidence of diarrhea reduced by 15% (RR: 0.85, 95% CI: 0.82–0.87) and incidence of measles by 50% (RR: 0.50, 95% CI: 0.37–0.67), while nonsignificant impacts on measles and acute respiratory infection-related mortality.</td>
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<td>Zinc supplementation</td>
<td>Height improved by 0.37 cm (SD 0.25) in children supplemented for 24 weeks, diarrhea reduced by 13%, pneumonia reduced by 19%, while nonsignificant impacts on mortality.</td>
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<td>Breastfeeding</td>
<td>EBF increase by 43% at 4–6 weeks with 89 and 20% significant increases in developing and developed countries, respectively. EBF also improves at 6 months by 137%, with six times increase in developing countries.</td>
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<td>Complementary/supplementary feeding</td>
<td>Statistically significant difference of effect for length during the intervention in children.</td>
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lower risk of anemia and a 74% lower risk of iron deficiency with higher serum hemoglobin and ferritin concentration, while nonsignificant impacts were observed for height-for-age and weight-for-age [11]. Zinc supplementation at a dose of 10 mg zinc/day for 24 weeks could lead to a net gain in height of 0.37 cm (±0.25) [12] and reduce the incidence of diarrhea by 13% and pneumonia morbidity by 19%, while has nonsignificant effects on mortality [13]. MMN supplementation with 3 or more micronutrients in children showed small effect sizes for length/height and weight, with limited evidence for an impact on outcomes such as morbidity and cognitive function [14].

**Micronutrient Fortification and Agricultural Interventions**

Food fortification is a strategy that has been used safely and effectively to prevent vitamin and mineral deficiencies. It has the advantage of reaching a wider at-risk population through existing food delivery systems, without requiring major changes in existing consumption patterns and also is cost-effective. Many programs have been initiated and are in place, but few have
been formally evaluated to assess its actual impact. A review of MMN fortification in children showed an increase in hemoglobin levels and a 57% reduced risk of anemia. Fortification is also associated with increased vitamin A serum levels. A review on mass salt fortification with vitamin A and iodine concluded that the fortified and iodized salt can improve the iodine status [15]. Zinc and vitamin D fortification has been effective, as evaluated by various programs. The evidence from developing countries however is scarce, and these programs also need to assess the direct impact of fortification on morbidity and mortality.

Bio-fortification is a relatively new strategy to improve iron, zinc, and vitamin A status in low-income populations. It is the use of conventional breeding techniques and biotechnology to improve the micronutrient quality of staple crops. A review on bio-fortification concluded that it has the potential to contribute to increased micronutrient intakes and improve micronutrient status; however, this domain requires further research [16].

Agricultural interventions including home and school gardening also have potential. A review on agricultural interventions to improve nutritional status of children concluded that home gardening interventions had a positive effect on the production of the agricultural goods and consumption of food rich in protein and micronutrients. Some evidence of a positive effect on absorption of vitamin A was also observed. However, the impacts on iron absorption and anthropometric indices remained inconclusive [17].

**Improving Feeding and Energy Intake**

Besides the micronutrient supplementation, macronutrient interventions have also been proposed and evaluated in accordance with the maternal needs during pregnancy, which includes dietary advice, balanced protein-energy (BEP) supplementation and high protein, isocaloric protein supplementation. A review [18] shows that providing pregnant females with BEP supplementation results in a significant reduction of 34% in the risk of giving birth to an SGA infant and 38% reduction in stillbirth, and results in an increased birthweight. These effects were more pronounced in malnourished women when compared to adequately nourished women.

In children, improved feeding in early infancy and the initial years of life holds an utmost importance, and breastfeeding and complementary feeding are strategies which ensure optimum nutrition during this vital phase of growth and development. Breastmilk provides numerous immunologic, psychologic, social, economic and environmental benefits; it is a natural first food
and ideal nutrition for the newborn [19]. Breastfeeding is therefore recommended as the optimal strategy for feeding newborns and young infants. Strategies to improve the uptake of breastfeeding are essential, and evidence suggests that breastfeeding education and promotion interventions are effective in improving breastfeeding rates and are associated with improved exclusive breastfeeding rates (EBF) of 43% at 4–6 weeks, with 89 and 20% significant increases in developing and developed countries, respectively. EBF also improved at 6 months by 137%, with six times increase in developing countries compared to a 1.3-fold increase in developed countries [20].

Complementary feeding for infants refers to the timely introduction of safe and nutritional foods in addition to breastfeeding, typically provided to children from 6 to 24 months of age [21]. Multiple complementary nutrition interventions targeted to improve nutritional status of children have been reviewed. These include complementary and supplementary feeding programs with or without nutrition education. Dewey and Adu-Afarwuah [22] reviewed the effectiveness and efficacy of complementary feeding interventions in children aged 6–24 months in developing countries and indicated that provision of complementary food can have a significant impact on growth under well-controlled situations. Complementary food combined with maternal education improved weight and linear growth. A recent review [23] looking at the impact of supplementary feeding that covered energy-protein supplementation found a statistically significant difference of effect for length during the intervention in children aged less than 12 years of age.

**Disease Prevention and Management**

Recurrent illnesses contribute to undernutrition burden, and strategies devised at the prevention and treatment of recurrent infections can contribute to addressing the existing undernutrition. These include the Water, Sanitation and Hygiene (WASH) interventions, interventions for prevention and treatment of diarrhea and malaria.

A review drawing upon three systematic reviews focused on the effect of hand washing with soap on diarrhea, of water quality improvement and of excreta disposal. It concluded that hand washing with soap significantly reduces diarrhea morbidity by 48%. The effect of improved water quality on diarrhea morbidity also appears similarly large with a 17% reduction, while there is very little rigorous evidence for the health benefit of sanitation [24].

WHO recommends that all schoolchildren should be treated at regular intervals with deworming drugs in helminthic-prevalent areas. A recent review
[25] shows that treating children after screening for worms with a single dose of deworming drugs may increase weight and hemoglobin. Administration of a single dose of antihelminthics in the second trimester of pregnancy failed to show a statistically significant impact on maternal anemia or LBW, preterm births and perinatal mortality. Effective interventions to prevent malaria morbidity and mortality include insecticide-treated mosquito nets, indoor-residual spraying and intermittent preventive therapy. A review [26] concludes that antimalarials when given to prevent malaria in pregnant women increased mean birthweight and reduced the incidence of LBW by 43% and severe antenatal anemia by 38% [26]. Therapeutic zinc supplementation for the management of diarrhea reduces all-cause mortality by 46% and diarrhea-related hospitalization by 23% [27].

**Conclusion**

We have the evidence for multiple interventions which work at various levels of care and, if implemented at scale, have the potential to reduce undernutrition burden globally. The long-term sustainability of such programs, however, is hindered in developing countries because of government policies, human resource constraints, bad communication networks including roads and the fragile health system infrastructure and participant compliance. Hence, the universal coverage with the full package of proven interventions could be the way forward in achieving the MDGs. Another important factor to consider is the cost-effectiveness of the proposed package. In the Copenhagen consensus statement 2012 [28], it was concluded that for about USD 100 per child, a bundle of interventions including micronutrient provision, complementary foods, treatments for worms and diarrheal diseases, and behavior change programs, could reduce chronic undernutrition by 36% in developing countries. Even in very poor countries, each dollar spent reducing chronic undernutrition has at least a USD 30 payoff.

All that is required is a global consensus on the package of interventions to be implemented and an agreed upon mode of delivery which ensures effective uptake and access to populations who need it most.

**Disclosure Statement**

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