Consequences of Under- and Overnutrition in Early Childhood

Under- and Overnutrition in the First Thousand Days: The Importance of the Problem and Interventions
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The Economic Rationale for Micronutrient Fortification
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Under- and Overnutrition of Iron in Infancy and Early Childhood
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Key Messages
Both maternal undernutrition and obesity are huge public health problems associated with adverse outcomes. It is estimated that close to 27% of all births in low- and middle-income countries may be small for gestational age and associated with maternal malnutrition.

Maternal obesity is associated with a high risk of adverse maternal outcomes and an excess risk of macrosomic babies, birth asphyxia or trauma and newborn mortality. Improved maternal weight and accelerating linear growth from birth to 2 years of age is associated with large gains in human capital with no excess of adult cardiovascular risks.

Although the boundaries for effective interventions have been suggest ed as the first 1,000 days (i.e. the period of pregnancy and the first 2 years of age), there may be benefits from interventions beyond these boundaries, better gains from interventions delivered preconceptionally and also continued gains in health and cognitive development even after 24 months of age.

Mothers (period between 0 and 6 months)
- Adequate diet and rest
- Iron
- Vitamin A
- Support for breastfeeding at home and workplace

Mothers (from “– 9” months to 0 – birth)
- Adequate diet and rest
- Tetanus toxoid immunization
- Intestinal and respiratory infections
- Supplementation (folic acid, iron folate acid, vitamin C, zinc, vitamin A)
- Food
- Tobacco cessation
- Non smoking
- Calcium supplementation
- Breastfeeding
- Obesity prevention

Infants (from 6 months to 24 months)
- Adequate diet and rest
- Iron
- Vitamin A
- Support for breastfeeding at home and workplace

Infants (from 0 and 6 months)
- Early initiation of breastfeeding
- Exclusive breastfeeding
- Essential newborn care
- Deworming
- Malaria prevention and treatment
- Obesity prevention

While the focus on the first 1,000 days makes operational sense, it is important to recognize that the concept assumes that the boundaries for effective interventions remain the period of pregnancy and the first 2 years of age. This may not be true operationally or physiologically as some of the more effective interventions may be in the preconception period [6], and, while interventions to impact stunting may be maximally effective in the first 24 months after birth [2,7], there may be significant gains in cognitive development even thereafter. This finding underscores the importance of considering the first 2 days as illustrative and not absolute limits for action (fig. 1).

References
The economic rationale for micronutrient fortification

**Key Messages**

Micronutrient deficiencies remain a significant global health challenge. Deficiencies may not only have adverse effects on the quality of people’s lives but may also result in significant developmental and social consequences.

Reducing micronutrient deficiencies through effective policies and targeted nutrition intervention strategies can bring significant health benefits for people, thus positively impacting their local economies.

The burden of malnutrition and micronutrient deficiencies remains a significant global health challenge, in low-income societies as well as in developed nations. The World Health Organization (WHO) estimates that more than 2 billion people are deficient in essential vitamins and minerals, particularly vitamin A, iodine, iron and zinc. Pregnant and lactating women and young children are most vulnerable to these deficiencies.

Iron deficiency is the most common nutritional deficiency as the WHO estimates that approximately 1.62 billion people worldwide are anemic. Preschool children (47%) and pregnant women (42%) have the highest prevalence of anemia.

The highest prevalence of micronutrient deficiencies for iron, vitamin A and zinc occurs in the lower socio-economic strata in Filipino children aged 6–23 months (Fig. 1).

Due to myriad biological functions of iron, even mild iron deficiency can have significant detrimental effects such as poor pregnancy outcome, poor motor and mental performance in children and decreased work productivity in adults. This can adversely affect people’s overall quality of life and have an impact on their local economy.

In 2003, Horton and Ross estimated the economic losses due to iron deficiency in 10 developing countries. The median losses for total physical and cognitive losses resulted in USD 16.78 per capita (4.05% of GDP). This amount is equivalent to the health-care expenditure in India in 2011.

Food fortification is a safe and cost-effective strategy to help prevent micronutrient deficiencies in a wider population. A systematic review confirmed that fortification resulted in a significant increase in serum micronutrient concentrations in children. A subsequent systematic review of the effects of micronutrient-fortified milk and cereals showed that iron multi-micronutrient fortification reduced the risk of anemia by 57% in infants and children compared to non-fortified food.

Medical costs and production losses by SES in 6–59 month-old children

Though the health benefits of fortification are well documented, recent research has begun to evaluate the benefits of fortification from the public health and economics perspective. A health economics model can be used to evaluate the economic effectiveness of micronutrient fortification strategies, including cost-of-illness and burden-of-disease studies. This approach is currently being applied in the Philippines, where the prevalence of micronutrient deficiencies (iron, vitamin A, zinc) in children aged 6–23 months and 24–59 months in the lower socio-economic strata leads to substantial costs (Fig. 2). The costs for these deficiencies in the Philippines amount to medical costs of USD 30 million, production losses of USD 618 million and the intangible costs of 4,000 complete life spans (in DALYs – disability-adjusted life year).

These estimated costs support the importance of early targeted nutrition and fortification strategies, especially for women and children. Reducing micronutrient deficiencies through effective policies and interventions can bring significant health benefits for people, thus positively impacting their local economies.

**References**

Key Messages
Iron supplementation/fortification will prevent iron deficiency and iron deficiency anemia in many infants who need iron, but infants with adequate iron status provided iron may be at risk for adverse outcomes.

Undernutrition of iron, or what we usually call iron deficiency (ID), is the most common micronutrient deficiency in older infants and toddlers in both underprivileged and privileged countries [1]. It is caused by a high requirement for iron due to rapid growth, a lack of iron in the diet and/or poor bioavailability of the dietary iron. ID in its pronounced form causes anemia (IDA) and is a risk factor for poor health [2]. IDA may, in turn, cause delays in cognitive and motor development [3], and these impairments appear to be irreversible, i.e. even with iron treatment the deficits can be manifested at older age. To prevent these long-term effects on the development, the provision of iron supplements [4] or fortification [5] of commonly used foods is recommended, coupled with dietary advice on how to select iron-rich foods.

The possibility of overnutrition of iron, i.e. excessive iron provision, has received limited attention. Although iron can cause accidental poisoning due to its toxicity, it has generally been believed that the doses of iron provided in iron supplements and ironfortified foods are modest and that any excess would be excreted. However, some studies suggest that providing iron to infants with adequate iron stores may have adverse effects. Iron drops given to iron-replete Honduran and Swedish infants aged from 4 to 9 months resulted in significantly decreased length gain [6]. This adverse effect was not observed in infants who initially had a low iron status. Several other studies in developing countries [7–9] have shown decreased weight gain in infants who were iron-replete at the start of the supplementation. In these populations, the nutritional status of the infants was generally poor, and their growth was faltering, which may explain why an effect was found on weight but not on height. The mechanism behind this growth-limiting effect of iron is not yet known. It is possible that the gut microflora of iron-replete infants given iron was different than that of iron-deficient infants given iron. Moreover, the gut microflora has recently been shown to affect energy utilization in the gut [10].

The above observations were made in infants receiving iron drops (medicinal iron). It has been thought that providing iron in infant formula is less likely to have adverse effects as a relatively small percentage of the iron is absorbed. It was recently shown, however, that feeding infants formula fortified with iron at a level of 12.7 mg/l as compared to 2.3 mg/l from 6 to 12 months of age resulted in better cognitive development outcomes at 10 years of age when their hemoglobin levels were lower than 105 g/l at the start of the intervention, but poorer outcomes when they were higher than 128 g/l [11]. Again, the mechanism behind this observation is not known. Taken together, it is apparent that some caution about providing excess iron to infants with an adequate iron status is warranted.

References