Maternal & Child Nutrition

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Consequences of Malnutrition in Early Life and Strategies to Improve Maternal and Child Diets through Targeted Fortified Products

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Introduction

Consequences of malnutrition in early life and strategies to improve maternal and child diets through targeted fortified products

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This supplement brings together papers focusing on the critical 1000 days of human development from pregnancy until 2 years of age. It is the third in an annual series first published as a Special Supplement of the Food and Nutrition Bulletin in June 2009. Diets of poor nutritional quality during pregnancy, infancy and early childhood lead to nutrient intakes, which do not meet requirements. This, combined with frequent infections during early childhood, results in deficits in growth (stunting), limited psychosocial development, increased risk of mortality, and reduced learning capacity and productivity later in life among those that survive. Programmes need to prevent these deficits by improving maternal and child nutrient intake in addition to preventing and treating infections.

Over the past 3 years, the community of nutrition scientists and researchers, activists and development practitioners committed to an integrated approach to nutrition programming has grown. This community advocates for a greater focus on maternal, infant and young child nutrition (MIYCN), the application of a lifecycle approach to programming and the breaking down of the barriers between expertise and sectors that limit the scale-up of cost-effective programmes that meet the needs of vulnerable populations on a sustained basis. This MIYCN supplement continues to reflect and contribute to this movement by providing the results of leading-edge research to inform technical consensus, programme design, policy and further research. It discusses the consequences of malnutrition in early life and focuses on programme-related research to improve nutrient intake through breastfeeding, promoting consumption of special formulated fortified foods that fill nutrient gaps or enhance the diets of women and children. It also presents research assessing feeding practices and preferences of caregivers in relation to child feeding and formulated products. An operations research project in China is described that illustrates how these activities were brought together in an integrated programme to improve nutrient intake in young children.

Dewey and Begum (2011) set the stage by summarizing the prevalence, causes and consequences of stunting. One-third of children under 5 years of age in developing countries are stunted, with many children in several regions already stunted at birth. Stunting rates increase during the first 24 months of life with little change thereafter until adolescence, when delayed maturation and an extended growth period result in some compensatory growth (Bosch et al. 2008). Thus, rates of stunting are lower in adult women than in young girls, but in some areas (South/ Southeast Asia and Latin America) maternal stunting rates can exceed 15%. The process of becoming stunted results in higher mortality, increased risk of chronic diseases in adulthood, lower adult height and permanent cognitive impairments. However, there is encouraging evidence that nutritional interventions in pregnancy and early life can reduce stunting and its negative consequences.

Micronutrient deficiencies are common during pregnancy and studies have attempted to determine the optimal formulation of products fortified with nutrients to address maternal deficiencies and subsequently improve pregnancy outcome. The review conducted by Yang and Huffman (2011) identified vitamin- and mineral-fortified products developed specifically for pregnant and lactating women and examined their impacts on maternal nutritional status and growth, birth outcomes and development of their offspring. They report that the use of micronutrient-fortified beverages and supplementary foods during...
pregnancy had positive effects on preventing maternal anaemia and iron deficiency. When consumed during pregnancy, those products containing milk and/or essential fatty acids increased mean birthweight, and a few studies have shown that they also improved birth length and reduced rates of preterm delivery.

Huffman et al. (2011) report on the importance of essential fats during pregnancy and early childhood. However, intakes among pregnant and lactating women and young children are often less than required. Increasing intake of foods rich in omega-3 fatty acids is needed, though their availability is often lacking in developing countries and costs of foods that are good sources of omega-3s are frequently high. Products for pregnant and lactating women such as milk fortified with omega-3 fatty acids or lipid-based nutrient products have been shown to have positive impacts, but more research is needed. Improving omega-3 intake in young children through enhanced breastfeeding practices and intake of foods with optimal omega-3 content (including animal products, especially fish, and products made with full fat soy or soy oil) will improve children's omega-3 fatty acid status and may improve growth and development.

Soekarjo and Zehner (2011) illustrate that many countries do not have the legal and policy environment necessary to support exclusive and continued breastfeeding. Using examples from Indonesia, they identify legislative requirements for supporting breastfeeding, including improved information, training, monitoring and enforcement systems for the Code of Marketing of Breastmilk Substitutes as well as policy changes to ensure implementation and monitoring of the Baby Friendly Hospital Initiative. These are needed because in spite of existing laws, there are reports of health centre and retail promotion of infant formula, follow-up formula and complementary foods for infants under 6 months, with little or no public sector action to address these Code violations. They suggest that baby-friendly hospital practices be included within accreditation criteria for hospitals.

They also report on the need to establish a registration category for complementary food supplements (CFS) to enhance availability of high-quality, low-cost fortified products to help improve young child feeding. In addition, guidelines for marketing these products for 6–24 month-olds are needed, so as to promote proper use and not interfere with breastfeeding. Complementary foods and supplements need to be distinguished from breast milk substitutes in legislation and policy guidance.

Pelto and Armar-Klemesu (2011) assess the potential of a commercial complementary food, using traditional market research techniques combined with anthropological methodologies. This focused ethnographic study (FES) was conducted among families with children 6–24 months of age living in a range of conditions, from dense urban neighbourhoods to peri-urban areas in Accra, Ghana. More than half of the children were fed Cerelac®, a commercial, fortified, instant porridge that is sold ready to mix with water or milk. Traditional millet porridges (koko) were also very common, but generic or branded commercial, non-instant cereals (Weanimix and Tom Brown) were seldom fed to children. Mothers were aware of the nutritional advantages of milk and the value of adding fish powder, ground roasted peanuts, soy flour, and/or oil to traditional koko. However, these ingredients were not usually readily available in the urban and peri-urban neighbourhoods. Mothers’ beliefs and practices were aimed at furthering the health, well-being and development of children (i.e. nurturance), and the healthiness of the foods they gave their children was of primary importance.

Convenience was also a major concern for caregivers. Cerelac® was considered the most convenient because packets could be obtained from neighbourhood kiosks quickly and easily with a small cash outlay. Because it is instant, it requires no cooking, which was another major component of convenience. Millet porridge was also considered very convenient because it could be purchased ready-made from a koko seller. Caregivers had to balance these two important concerns (nurturance, as reflected in the healthiness of the food and convenience) with cost. Mothers often fed low-cost, traditional porridges because of cost concerns, but when they did so, they felt they were not giving their children the best foods for their health. Thus, finding a lower cost alternative
to Cerelac®, that is instant and fortified at higher levels (so as to meet more of the child’s needs through fewer servings per day) would be important for caregivers. Alternatively, a CFS that could be used to fortify the traditional porridge would also provide an important choice for caregivers.

The FES tool used by Pelto and Armar-Klemesu (2011) and has now also been adapted and used to assess the potential for marketing complementary foods and supplements in South Africa, Philippines and Afghanistan.

A different type of formative data collection was conducted by Tripp et al. (2011) in Niger, where they assessed the acceptability of a multiple micronutrient powder (Sprinkles®) and lipid-based nutrient supplement (Nutributter®) among rural and urban families. Focus group discussions were held among mothers, fathers and grandmothers of children 6–23 months of age, and 80 mothers who participated in a home study were interviewed about their views on these two products. Nutributter® was the preferred product, although both Sprinkles® and Nutributter® were well accepted by children 6–23 months of age. Caregivers reported a willingness to pay for both products, agreeing to pay higher amounts for Nutributter®. Although most mothers had intended to mix the Nutributter® into the child’s food (boule), more mothers ended up giving the Nutributter® directly because their children preferred to eat it that way, there was less waste when the child did not finish the boule, and it was easier for mothers since the child could feed him/her self.

As new CFS are developed locally, there is a need to interpret international guidelines on nutrient requirements to determine actual amounts of nutrients to include in products. The iron absorption rate from sodium iron ethylenediaminetetraacetate (NaFeEDTA) is about two to three times greater than that from either ferrous fumarate or ferrous sulfate in diets high in phytate, which are common in developing countries. NaFeEDTA is also highly effective and has few organoleptic problems. However, EDTA should not be consumed in excessive levels and Food and Agriculture Organization/World Health Organization have established an acceptable daily intake (ADI) for EDTA. The paper by Yang, Siekmann and Schofield (2011) explores one way of determining how much NaFeEDTA should be included in a product so as not to exceed the ADI for EDTA.

Because the ADI for EDTA is given per kilogram body weight, the actual amount of NaFeEDTA to include in a CFS serving children of different ages needs to be decided upon. Yang, Siekmann and Schofield explore this issue by using the distribution of weights of children based on different prevalences of malnutrition. The clarification of how such levels can be determined is important so that others can understand the reasoning behind levels of nutrients in products.

Calculations were conducted using the reference of 6–8-month-old infants, because they would be at highest risk of consuming levels of EDTA above the ADI because of their lower weights than older children. If 2 mg NaFeEDTA were to be given to 6–8-month-old infants, the percentage exceeding the ADI for EDTA would be <10% for populations with <30% of children who are underweight. However, if 2.5 mg iron were given in NaFeEDTA form to all 6–8-month-old infants, 30–64% of infants would be above the ADI for EDTA. Such quantification of the risks of different doses of nutrients is useful for setting policies and developing standards for products.

A public–private partnership that brings together many of the issues discussed in the preceding papers was implemented in Shan’xi province, in the north of China (Sun et al. 2011). A CFS (Ying Yang Bao-YYB) made from full-fat soy powder and fortified with multiple micronutrients (including NAFeEDTA) was produced and marketed by a private sector company. Social marketing materials were developed by the China Center for Disease Control (CDC) and the Capital Pediatrics Institute who worked with health centres to train staff on the importance of continued breastfeeding and use of YYB to improve child nutrition. Because there had been no category for a CFS needed to market the product, China CDC worked with the National Standardization Administration to develop and get approval for a CFS standard, the first ever. This standard is shown in their paper, and can serve as an example as other countries develop regulations for local products. In the end-line survey, more than half (60%) of caregivers knew about YYB and of
those, 23% had ever purchased it (13.5% of all caregivers). More than 95% of the target children consumed the product at least three times per week. The risk of anaemia was greatly reduced among those children compared with those in families that did not purchase the product. The prevalence of early initiation of breastfeeding, minimal dietary diversity, minimal acceptable diet and consumption of iron-rich food improved significantly following the intervention. However, the authors emphasize that investments in demand creation need significant time and effort, and marketing needs to be harmonized with Behaviour Change Communication.

Dewey and Mayers (2011) illustrate the negative impact of infections on child growth. Of major concern are diarrhoeal and respiratory infections, as well as subclinical infections, especially environmental enteropathy. They conclude that interventions that combine improved nutrition with prevention and control of infections are likely to be most effective for enhancing child growth and development. Promotion of breastfeeding has the dual benefit of reducing infection and improving nutrition. Use of instant or ready-to-use fortified complementary foods or supplements (such as lipid-based nutrient supplements) can reduce the risk of infection because they can be easily prepared prior to serving, reducing the likelihood of contamination when refrigeration is not available. Feeding during and after illness can help to sustain adequate nutrient intake and promote catch-up growth. Programmes that combine nutrition objectives with the other components required for prevention and control of infections (e.g. water quality, sanitation, malaria control) are also needed.

Acknowledgements

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Conflict of interest

No conflicts of interest exist.

References

This review summarizes the impact of stunting, highlights recent research findings, discusses policy and programme implications and identifies research priorities. There is growing evidence of the connections between slow growth in height early in life and impaired health and educational and economic performance later in life. Recent research findings, including follow-up of an intervention trial in Guatemala, indicate that stunting can have long-term effects on cognitive development, school achievement, economic productivity in adulthood and maternal reproductive outcomes. This evidence has contributed to the growing scientific consensus that tackling childhood stunting is a high priority for reducing the global burden of disease and for fostering economic development. Follow-up of randomized intervention trials is needed in other regions to add to the findings of the Guatemala trial. Further research is also needed to: understand the pathways by which prevention of stunting can have long-term effects; identify the pathways through which the non-genetic transmission of nutritional effects is mediated in future generations; and determine the impact of interventions focused on linear growth in early life on chronic disease risk in adulthood.

Keywords: stunting, malnutrition, child growth, supplementary feeding, child development, economic development.

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Introduction

Children throughout the world can reach their growth potential if they are nurtured in healthy environments and their caregivers follow recommended health, nutrition and care practices. Stunting indicates a failure to achieve one’s genetic potential for height (Golden 2009). A child is considered ‘stunted’ if his or her height is more than two standard deviations below the World Health Organization standard (WHO Multicentre Growth Reference Study Group, 2006). The main causes of stunting include intrauterine growth retardation, inadequate nutrition to support the rapid growth and development of infants and young children and frequent infections during early life (Frongillo 1999). Although a child may not be classified as ‘stunted’ until 2–3 years of age, the process of becoming stunted typically begins in utero. The result – a very short height – usually reflects the persistent, cumulative effects of poor nutrition and other deficits that often span across several generations. This review summarizes the impact of stunting, highlighting research findings published in the past 5 years.
Stunting affects one-third of children under 5 in low-income and middle-income countries, for a total of 178 million children (Black et al. 2008). Stunting often goes unrecognized by families who live in communities where short stature is so common that it seems normal. Even among health workers, stunting generally does not receive the same attention as underweight or wasting (low weight for height), especially if height is not routinely measured as part of community health programmes. Many families, health workers and policy makers are unaware of the consequences of stunting so it may not be viewed as a public health issue.

The prevalence of stunting is highest in Africa (40%), and the largest number of stunted children is in Asia (112 million), mostly in South-central Asia, as shown in Table 1. Ninety per cent of the overall global burden of child stunting is attributable to 36 countries. Stunting is found at many levels in society. In Bangladesh, for example, stunting in children less than 5 years of age was found in one-fourth of the richest households [National Institute of Population Research and Training (NIPORT) et al. 2009]. In developing countries, stunting is more prevalent than underweight (low weight for age, 20%) or wasting (low weight for height, 10%) possibly because height gain is even more sensitive to dietary quality than is weight gain.

### Stunting often begins in utero

During fetal life and the first 2 years after birth, nutritional requirements to support rapid growth and development are very high. Average height-for-age

| Table 1. Stunting in children under 5 years of age, based on WHO Child Growth Standards
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Children &lt;5 years in millions</td>
<td>Number stunted in millions</td>
<td>Percentage stunted</td>
</tr>
<tr>
<td>Africa</td>
<td>142</td>
<td>57</td>
</tr>
<tr>
<td>Eastern</td>
<td>49</td>
<td>24</td>
</tr>
<tr>
<td>Middle</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Northern</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>Southern</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Western</td>
<td>45</td>
<td>17</td>
</tr>
<tr>
<td>Asia</td>
<td>357</td>
<td>112</td>
</tr>
<tr>
<td>Eastern</td>
<td>95</td>
<td>14</td>
</tr>
<tr>
<td>South-central</td>
<td>181</td>
<td>74</td>
</tr>
<tr>
<td>Southeast</td>
<td>55</td>
<td>19</td>
</tr>
<tr>
<td>Western</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>57</td>
<td>9</td>
</tr>
<tr>
<td>Caribbean</td>
<td>4</td>
<td>0.3</td>
</tr>
<tr>
<td>Central America</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>South America</td>
<td>37</td>
<td>5</td>
</tr>
<tr>
<td>All developing countries</td>
<td>556</td>
<td>178</td>
</tr>
</tbody>
</table>


z-scores are already low at birth (below 0, the standard score or population average) in several regions and decline sharply during the first 24 months of life but show no further decline or any improvement thereafter (Victora et al. 2010), as illustrated in Fig. 1.

Maternal undernutrition, anaemia, tobacco use and indoor air pollution can restrict fetal growth and result in low birthweight. Table 2 shows that the prevalence of low body mass index (BMI) among women 15–49 years of age may be as high as 35% in some countries. In many countries, more than half of

### Key messages

- Stunting is both a direct cause of short adult height and suboptimal function later in life and a key marker of the underlying processes in early life that lead to poor growth and other adverse outcomes.
- Stunting is a risk factor for diminished survival, childhood and adult health, learning capacity and productivity.
- Prevention of stunting should be made a priority. Intervention strategies should target the ‘window of opportunity’ from the pre-conception period through the first 2 years of life and include interventions demonstrated to have a positive impact on linear growth.
- Additional research is needed to confirm findings for other regions, to understand the pathways through which stunting can have long-term effects and to identify pathways through which the non-genetic transmission of nutritional effects is mediated in future generations.
all women of reproductive age are anaemic (Fig. 2). Diets of poor nutritional quality during pregnancy, infancy and early childhood lead to inadequate nutrient intake. Frequent infections during the first 2 years of life also contribute to the high risk of becoming stunted during this period.

Children who are stunted usually grow up to be stunted adults (Martorell et al. 1994). An opportunity exists to make up some of the height deficit during adolescence because stunted children often experience a delay in skeletal maturation, lengthening the total period of time for growth in height. However, the potential for substantially reducing the height deficit during adolescence is limited because the maturational delays are usually shorter than 2 years (Martorell et al. 1994). Moreover, adolescents who enter this period stunted are often living under the same adverse nutritional, socio-economic and environmental conditions that triggered stunting when they were young children.

**Consequences of stunting**

Childhood stunting is related to long-term consequences in two ways:

- as a direct cause of short adult height and suboptimal function later in life and
- as a key marker of the underlying processes in early life that lead to poor growth and other adverse outcomes.

Scientific understanding of stunting as a direct cause of adverse consequences is incomplete, in part because most of the evidence comes from observational studies. Nonetheless, there is growing evidence...
of the connections between slow growth in height in early life and impaired health and educational and economic performance later in life.

The Maternal and Child Undernutrition Study Group (Victora et al. 2008) reviewed cohort studies from five low-income and middle-income countries: Brazil, Guatemala, India, Philippines and South Africa. The studies involved long-term follow-up of children into late adolescence and adulthood. The study group concluded that small size at birth and childhood stunting were linked with short adult stature, reduced lean body mass, less schooling, diminished intellectual functioning, reduced earnings and lower birthweight of infants born to women who themselves had been stunted as children. Recent evidence also indicates that children born to women who are stunted are at greater risk of dying than children of mothers with normal height (Ozaltin et al. 2010). The links between stunting and health, educational and economic outcomes are discussed below and illustrated in Fig. 3.

### Long-term health consequences of maternal stunting

A woman who is less than 145 cm or 4'7" is considered to be stunted, which presents risks to the survival, health and development of her offspring. Table 2 shows the percentage of women of reproductive age who are stunted. The prevalence of stunting among women is highest in South/Southeast Asia (e.g. 15% in Bangladesh) and in parts of Latin America (e.g. 29% in Guatemala).

Maternal stunting can restrict uterine blood flow and growth of the uterus, placenta and fetus. Intrauterine growth restriction (IUGR) is associated with many adverse fetal and neonatal outcomes (Kramer 1987; Kramer et al. 1990; Black et al. 2008). During pregnancy, IUGR may lead to chronic fetal distress or fetal death. If born alive, the growth-restricted infant is at higher risk for serious medical complications (Black et al. 2008). Infants with IUGR often suffer from delayed neurological and intellectual development, and their deficit in height generally persists to adulthood.

Maternal stunting is consistently associated with an elevated risk of perinatal mortality (stillbirths and deaths during the first 7 days after birth) (Lawn et al. 2009), mostly related to obstructed labour resulting from a narrower pelvis in short women. In a hospital-based study in Nigeria, obstructed labour accounted for 53% of perinatal mortality (Omolov-Ohonsi & Ashimi 2007). Perinatal mortality from obstructed labour is largely the result of birth asphyxia. Mothers

<table>
<thead>
<tr>
<th>Country and year of DHS</th>
<th>Height: percentage under 145 cm</th>
<th>Body mass index: percentage thin (&lt;18.5 kg m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Saharan Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benin 2006</td>
<td>1.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Burkina Faso 2003</td>
<td>0.5</td>
<td>20.8</td>
</tr>
<tr>
<td>Chad 2004</td>
<td>0.3</td>
<td>22.1</td>
</tr>
<tr>
<td>Congo DR 2007</td>
<td>4.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Ethiopia 2005</td>
<td>3.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Ghana 2008</td>
<td>1.4</td>
<td>8.6</td>
</tr>
<tr>
<td>Guinea 2005</td>
<td>1.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Kenya 2008–2009</td>
<td>1.2</td>
<td>12.3</td>
</tr>
<tr>
<td>Liberia 2007</td>
<td>2.5</td>
<td>10</td>
</tr>
<tr>
<td>Madagascar 2003–2004</td>
<td>6.5</td>
<td>19.2</td>
</tr>
<tr>
<td>Malawi 2004</td>
<td>3.1</td>
<td>9.2</td>
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<tr>
<td>Mali 2006</td>
<td>0.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Mozambique 2003</td>
<td>4.9</td>
<td>8.6</td>
</tr>
<tr>
<td>Namibia 2006–2007</td>
<td>1.0</td>
<td>15.9</td>
</tr>
<tr>
<td>Niger 2006</td>
<td>0.7</td>
<td>19.2</td>
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<tr>
<td>Nigeria 2008</td>
<td>3.0</td>
<td>12.2</td>
</tr>
<tr>
<td>Rwanda 2005</td>
<td>3.8</td>
<td>9.8</td>
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<td>Senegal 2005</td>
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<td>18.2</td>
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<td>Tanzania 2004–2005</td>
<td>3.4</td>
<td>10.4</td>
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<td>Uganda 2006</td>
<td>1.9</td>
<td>12.1</td>
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<td>Zambia 2007</td>
<td>2.6</td>
<td>9.6</td>
</tr>
<tr>
<td>Zimbabwe 2005–2006</td>
<td>0.7</td>
<td>9.2</td>
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<tr>
<td>South/Southeast Asia</td>
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<tr>
<td>Bangladesh 2007</td>
<td>15.1</td>
<td>29.7</td>
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<td>Cambodia 2005</td>
<td>7.7</td>
<td>20.3</td>
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<td>India 2005–2006</td>
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<td>Nepal 2006</td>
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<td>24.4</td>
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<tr>
<td>Latin America and the</td>
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<tr>
<td>Caribbean</td>
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<tr>
<td>Bolivia 2003</td>
<td>10.3</td>
<td>1.9</td>
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<tr>
<td>Guatemala 2008–2009</td>
<td>29.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Haiti 2005–2006</td>
<td>1.2</td>
<td>15.5</td>
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<tr>
<td>Honduras 2005–2006</td>
<td>9.8</td>
<td>4</td>
</tr>
<tr>
<td>Peru 2004–2008 continuous</td>
<td>11.2</td>
<td>1.8</td>
</tr>
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DHS, Demographic and Health Surveys.
with height shorter than 145 cm are more likely to have an infant with birth asphyxia (Lee et al. 2009). Globally, birth asphyxia accounts for 23% of the four million neonatal deaths each year (Lawn et al. 2005). An estimated one million children who survive birth asphyxia live with chronic neuro-developmental disorders, including cerebral palsy, mental retardation and learning disabilities (World Health Organization 2005).

In a recent analysis of 109 Demographic and Health Surveys (DHS) conducted between 1991 and 2008 in 54 countries, children (under 5 years of age) who were born to the shortest mothers (<145 cm) had a 40% increased risk of mortality after adjusting for multiple factors (Ozaltin et al. 2010). Although the percentage of mothers shorter than 145 cm is low in most countries, the analysis showed an elevated risk of child mortality with each lower category of mater-
nal height, compared with mothers ≥160 cm in height (adjusted relative risks of 1.06, 1.13, 1.23 and 1.40 for the height categories of 155–159.9, 150–154.9, 145–149.9 and <145 cm, respectively). The effect of short maternal stature on child mortality was comparable to the effect of having no education or being in the poorest 20% of households. The likely explanations for this finding include an elevated risk of perinatal death, for the reasons explained above, as well as longer-term effects of IUGR on child nutrition and immune function that increase the risk of child mortality.

As mentioned above, short maternal stature increases the risk of disparity in size between the baby’s head and the mother’s pelvis. Because of this disproportion, short mothers are less likely to have a
successful spontaneous vaginal delivery (Kwawukume et al. 1993; Merchant et al. 2001), which increases the risk of maternal mortality and short- and long-term disability. If timely referral to a well-equipped hospital occurs, a Caesarean section can be performed; however, even a Caesarean section carries potential risks of complications that can jeopardize maternal and newborn health. Failure to deliver by Caesarean section in time may lead to more serious consequences of obstructed labour. These consequences can include injury to the birth passage, post-partum haemorrhage, rupture of the uterus, genital sepsis or fistula, leading to urinary dribbling or incontinence. In the worst case scenario, obstructed labour can lead to maternal death, mostly because of ruptured uterus or puerperal sepsis. The percentages of maternal mortality attributable to obstructed labour are 4% in Africa, 9% in Asia and 13% in Latin America and the Caribbean (Khan et al. 2006).

Mothers who survive but have long-term disability due to complications such as fistula experience social, economic, emotional and psychological consequences that have an enormous impact on maternal health and well-being (Ahmed & Holtz 2007). Decreased maternal stature is also associated with an increased risk of underweight and stunting among offspring. In their analysis of DHS in 54 countries, Özaltin et al. (2010) found that a 1-cm decrease in height was associated with an increased risk of underweight and stunting. Compared with the tallest mothers (>160 cm), each lower-height category had a substantially higher risk of underweight and stunting among children, with the highest risk for mothers shorter than 145 cm. The association between maternal height and stunting was statistically significant in 52 of 54 countries (96%) analysed.

Growth restriction in early life is linked not only to short adult height but also to certain metabolic disorders and chronic diseases in adulthood. Data from the Maternal and Child Undernutrition Study Group (Victora et al. 2008) indicate that lower birthweight (which is strongly correlated with birth length) and undernutrition in childhood are risk factors for high glucose concentrations, blood pressure and harmful lipid profiles in adulthood after adjusting for adult height and BMI. The ‘developmental origins of health and disease’ hypothesis posits that the intrauterine and early postnatal environment can modify expression of the fetal genome and lead to lifelong alterations in metabolic, endocrine and cardiovascular function (Gluckman et al. 2010). In this case, it is likely that the process of stunting is harmful and not necessarily short stature itself.

Long-term educational and economic consequences of child stunting

The process of becoming stunted, due to restricted nutrient supply and/or frequent infection, is likely a common cause of both short stature and structural and functional damage to the brain, resulting in delay in the development of cognitive functions as well as permanent cognitive impairments (Kar et al. 2008). The Maternal and Child Undernutrition Study Group, using the same pooled cohort mentioned above, found that being stunted at 24 months was associated with a reduction in schooling of 0.9 year, an older age at school enrolment and a 16% increased risk of failing at least one grade in school after controlling for confounding variables such as sex, socioeconomic status and maternal schooling (Martorell et al. 2010a). Evidence from other developing countries also indicates that being stunted between 12 and 36 months of age is associated with poorer cognitive performance and lower school achievement in middle childhood (Grantham-McGregor et al. 2007). Short stature has also been linked to lower economic productivity. For example, in a large cross-sectional study in Brazil, a 1% increase in height was associated with a 2.4% increase in wages (Thomas & Strauss 1997). Taller men and women earned more even after controlling for education and other indicators of health such as BMI, per capita energy intake and per capita protein intake.

The most convincing evidence on these consequences comes from long-term follow-up studies of randomized trials, such as the large-scale nutritional supplementation trial carried out in Guatemala between 1969 and 1977 (Box 1, Fig. 4 and Table 3), the only one of the five cohort studies examined by the Maternal and Child Undernutrition Study Group that used an experimental design. Several recent
Box 1. The INCAP Longitudinal Study
In the Institute of Nutrition of Central America and Panama (INCAP) Longitudinal Study, supplements were made available to the villagers from four centrally located feeding stations, one in each village, where supplements were distributed daily at mid-morning and mid-afternoon. Attendance and supplement consumption were open to all villagers but were recorded only for the target population. Routine medical services in each village were established and maintained by INCAP. All women who were pregnant or lactating and all children from birth to 7 years of age living in the study villages between 1 January 1969 and 28 February 1977 were included in the original design of the study (Habicht & Martorell 1993). Supplementation was provided from 1 March 1969 to 28 February 1977. Children were followed through age 7 years or until the end of the study, whichever came first. Thus, all children were exposed either to Atole or to Fresco at different ages and for different periods of time: prenatally through supplement intake by the mother and post-natally through the effects of maternal supplement intake on breast milk content of certain nutrients, as well as through the child’s own consumption (Stein et al. 2008). The trial included 643 pregnant and lactating women and 2392 children 0–7 years of age who received supplementation. Several prospective follow-up studies were conducted between 1988 and 2007, and some are still ongoing or being planned (Fig. 4). Table 3 provides descriptive information about the follow-up studies conducted with this cohort.

Fig. 4. Prospective cohort studies nested in the follow-up of the Institute of Nutrition of Central America and Panama trial (Source: adapted from Ramirez-Zea et al. 2010).
Table 3. Follow-up studies for the INCAP longitudinal study

<table>
<thead>
<tr>
<th>Follow-up period</th>
<th>Objectives</th>
<th>Study participants</th>
<th>Study sample</th>
<th>Age at follow-up</th>
<th>Outcome variables</th>
<th>Potential confounders adjusted for</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2002–April 2004</td>
<td>To explore the impact of early childhood nutrition on adult human capital formation and economic productivity</td>
<td>Cohort members of INCAP 1969–1977 study who remained alive in 2004, living in or near four original study villages or elsewhere in Guatemala City</td>
<td>Targeted: 1855 (78%)* Interviewed = 1571 Completed data = 1424 (Men = 602; women = 505) Attrition rate = 40.5%</td>
<td>26–42 years</td>
<td>Cognitive function and schooling: • average years of schooling • reading comprehension score • intelligence score Income and wages: • annual earned income • hours worked in the last year • average wage rate</td>
<td>Individual characteristics: sex and age</td>
</tr>
<tr>
<td>Jan 2006–Oct 2007</td>
<td>To assess whether nutritional supplementation of girls aged &lt;7–15 years affected their offspring’s nutritional status</td>
<td>Cohort members of INCAP 1969–1977 study who remained alive in 2007, living in or near four original study villages or elsewhere in Guatemala City, and who had at least one offspring</td>
<td>Targeted: 1090 cohort members Interviewed = 1090 (558 women) of whom 824 (436 women) reported having 1400 living offspring &lt;12 years • 791 biological children of 401 mothers who had been exposed to supplementation and for whom data on all 10 anthropometric indicators were available were included in the analysis</td>
<td>29–44 year-old cohort and &lt;12-year-old offspring of cohort</td>
<td>Anthropometric indicators: Birthweight, height, weight, BMI, head circumference, arm circumference, triceps skinfold thickness, sub-scapular skinfold thickness, height-for-age z score, weight-for-age z score and BMI for age z score</td>
<td>Offspring sex and age. Assessed robustness of findings with regard to: sex of parents, maternal schooling attainment, paternal height, grandparent’s socio-economic status and grandmother’s height, excluding 12-year-old offspring</td>
</tr>
</tbody>
</table>

BMI, body mass index; INCAP, Institute of Nutrition of Central America and Panama.

*Among the 2392 original cohort members, 274 (11%) died, mostly from infectious diseases in childhood, 162 (7%) migrated abroad and 101 (4%) were untraceable; among 1855 eligible for interview, 1133 (60%) lived in the original villages, 155 (8.4%) lived in nearby villages, 419 (22.6%) lived in or near Guatemala City and 168 (9%) lived elsewhere in Guatemala.
papers have evaluated the impact of nutrition supplementation in early life on stunting and on various aspects of the development of human capital in adulthood. The Institute of Nutrition of Central America and Panama (INCAP) Oriente Longitudinal Study was a large supplementary feeding trial targeted to pregnant and lactating women and their children from birth to 7 years of age, which was conducted in four rural Guatemalan villages (Martorell et al., 1992). Subsequent follow-up studies occurred in 1988–2007 through backward tracing of the original population up to 40 years later (Ramirez-Zea et al. 2010). The trial included two sets of two matched villages. One village in each set was randomly selected to receive either a high-protein (6.4 g 100 mL⁻¹), high-energy (91 kcal 100 mL⁻¹) supplement called ‘Atole’ or a non-protein, low-energy (33 kcal 100 mL⁻¹) supplement called ‘Fresco’, the nutrient composition of which has been described elsewhere (Martorell et al. 1995; Ramirez-Zea et al. 2010). Dry skim milk was the predominant source of energy and protein in Atole. From October 1971 until the end of the intervention in 1977, both supplements were fortified with several micronutrients (iron, fluoride, thiamine, riboflavin, niacin, ascorbic acid and vitamin A) in equal concentrations by volume (Martorell et al. 1995). Fresco was given as a control for social interaction associated with attending the feeding centre, which might have influenced certain outcomes such as cognitive development.

Child length gain was greater in ‘Atole’ villages than in ‘Fresco’ villages during the first 3 years of life (+0.9 cm in the first year, +1.0 cm in the second year and +0.4 cm in the third year) (Schroeder et al. 1995). This effect persisted even after controlling for initial body size, diarrhoeal disease, socio-economic status, gender and energy from home diets during the second year. No effect of Atole on length gain was observed when supplementation occurred between 3 and 7 years of age. The greater impact during the first 3 years of life is probably due to the greater growth potential, greater relative nutritional requirements and relatively frequent infections in younger children.

The first follow-up study was conducted during 1988–1989 when the cohort was 11–26 years old. It documented that improved nutrition in early childhood had significant effects on body size and intellectual functioning (Martorell et al. 2010b). Specifically, during adolescence, subjects from Atole villages were taller, weighed more and had greater lean body mass than subjects from Fresco villages (Rivera et al. 1995). Subjects receiving Atole also scored significantly higher on tests of knowledge, numeracy, reading and vocabulary than those given Fresco (Pollitt et al. 1995).

Key findings from the 2002–2004 follow-up study, when the cohort was 26–42 years of age, included the impact on school achievement (Maluccio et al. 2009) and economic productivity (Hoddinott et al. 2008). These studies showed that exposure to Atole supplementation before 3 years of age, but not after 3 years, increased years of schooling completed by 1.2 grades for women (but not for men). Reading comprehension and intelligence scores increased in both men and women. The impact of Atole supplementation on intelligence was independent of schooling (Stein et al. 2008). Wage rate (income earned per hour worked) increased by US$0.62–0.67 per hour in men (but not in women). In the subgroup exposed to Atole supplementation during the first 2 years of life, this represented a 46% increase in average wages. The lack of effect on income measures in women could be due to differences in economic activity between men and women. Virtually all men (99%) participated in at least one income-generating activity, whereas the proportion was much less for women (70%) who were mostly engaged in activities that did not generate much income.

The 2006–2007 follow-up study (Behrman et al. 2009a) of intergenerational effects found that compared with the offspring of women exposed to Fresco, the offspring of women exposed to Atole as children (starting before 7 years of age) had greater birth-weight (+116 g), height (+1.3 cm), head circumference (+0.6 cm), height-for-age z-score (+0.26) and weight-for-height z-score (+0.20). The effects on height differed by sex of the offspring. Sons of women exposed to Atole were 2.0 cm taller than sons of women exposed to Fresco, whereas the difference for female offspring was only 0.6 cm. There were no significant differences in the measures of offspring adiposity (BMI, arm circumference, triceps skinfold thickness...
and sub-scapular skinfold thickness). Paternal exposure to Atole was not associated with any of the 11 anthropometric indicators.

This unique, long-term study demonstrated that nutritional intervention before 3 years of age has significant long-term effects on height, as well as human capital and economic productivity in adulthood, and that nutritional supplementation of girls starting in early childhood has significant effects on body size of their offspring.

In a subsequent analysis of the pathways by which Atole supplementation benefited wage rates in men (Behrman et al. 2009b), it was found that adult lean body mass (which is usually correlated with height) and adult reading comprehension scores were both explanatory variables. However, when both variables were treated as ‘endogenous’ (i.e. potentially reflecting earlier choices), only the reading comprehension scores remained significant in explaining the impact on wage rates. This does not mean that early life nutrition was not important but that it worked through reading comprehension scores and not through adult lean body mass. The lack of impact via lean body mass is probably explained by the relatively low proportion of men in the follow-up study who worked in physically demanding occupations. When analysis was restricted to men with such occupations, lean body mass remained important in explaining the impact of supplementation on wage rates. Thus, the relative importance of improvements in ‘brains’ vs. ‘brawn’ may depend on the types of employment available to adults.

Discussion

The studies discussed above provide strong evidence that stunting matters for two reasons. First, it strongly affects adult height, which among women has an impact on health and survival of their children, as well as their own reproductive health, and among men has been linked to economic productivity. Second, the process of stunting reflects damage that affects (in some cases, irreparably) health and development over the long term. The follow-up studies of the INCAP trial in Guatemala demonstrate that a nutritional intervention in early life that improves linear growth also has sizeable effects on human capital formation and economic productivity in adulthood, as well as on growth of future generations. They also show that intervention needs to occur during the period when stunting usually occurs – the prenatal period and the first 3 years of life – in order to have a significant impact.

Thus, efforts to prevent stunting are likely to be of benefit for multiple outcomes, including cognitive development, school achievement and wages earned in adulthood. In developing countries, an estimated 99 million children of primary school age are not enrolled in school, and of those enrolled, only 78% complete primary school [United Nations Educational, Scientific and Cultural Organization (UNESCO) 2010]. About 200 million children under 5 years of age fail to reach their potential in cognitive development because of a combination of risk factors such as poverty, poor health and nutrition and inadequate caring practices (Grantham-McGregor et al. 2007). These conditions play an important part in the intergenerational transmission of poverty (Grantham-McGregor et al. 2007). Therefore, interventions to prevent stunting early in life should accelerate achievement of the Millennium Development Goals of achieving universal primary education, eradicating poverty, reducing mortality and improving maternal health.

Making prevention of stunting a priority, however, will require that certain actions be taken by policy makers and those responsible for the design and implementation of programmes. Specifically, interventions need to be targeted at the ‘window of opportunity’, which includes the pre-conception period, pregnancy, lactation and the first 2 years of life (Bhutta et al. 2008; Dewey & Huffman 2009; Victora et al. 2010; Dewey & Adu-Afarwuah 2008). The choice of intervention strategies should be guided by those that have been demonstrated to have a positive impact on linear growth, not just child weight. Similarly, evaluation of programme impact must include measures of child height, not just weight. Lastly, policy makers should shift towards an emphasis on stunting as an indicator of overall child health and nutrition rather than underweight. This is particularly important as the ‘nutrition transition’ towards greater over-
weight accelerates in many developing countries, which can lead to populations with low rates of underweight but persistently high rates of stunting.

Research priorities

Additional research, especially research from intervention trials, is needed to better understand the long-term consequences of stunting in early life. Research from intervention trials in other regions is needed to add to the findings of the long-term follow-up of the intervention trial in Guatemala. We need to know whether interventions that improve linear growth of infants and young children in Africa and Asia are also beneficial for key outcomes later in life. The analysis by the Maternal and Child Undernutrition Study Group (Victora et al. 2008) using data from four prospective cohort studies from Brazil, India, Philippines and South Africa (in addition to the Guatemala trial) suggests that this will be the case; however, follow-up of randomized intervention trials is the gold standard for drawing such conclusions.

Further research is also needed to understand the pathways by which prevention of stunting can have long-term effects on cognitive development, school achievement and economic productivity in adulthood, particularly in populations where labour force participation among women is high. What are the direct effects of increased height, and for which outcomes is greater height simply a marker of improvement in other domains such as cognitive function? More information on the consequences for maternal reproductive outcomes and parental caregiving practices is needed.

Finally, research is needed to identify the pathways through which the non-genetic transmission of nutritional effects is mediated in future generations and to determine the impact of interventions focused on linear growth in early life, rather than accelerated weight gain, on chronic disease risk in adulthood.

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Conflicts of interest

No conflicts of interest have been declared.

References


Review of fortified food and beverage products for pregnant and lactating women and their impact on nutritional status

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Abstract

Fortified beverages and supplementary foods, when given during pregnancy, have been shown to have positive effects on preventing maternal anaemia and iron deficiency. Studies show that use of micronutrient fortified supplementary foods, especially those containing milk and/or essential fatty acids during pregnancy, increase mean birthweight by around 60–73 g. A few studies have also shown that fortified supplementary foods have impacts on increasing birth length and reducing preterm delivery. Fortification levels have ranged generally from 50% to 100% of the recommended nutrient intake (RNI). Iron, zinc, copper, iodine, selenium, vitamins A, D, E, C, B1, B2, B6, and B12, folic acid, niacin and pantothenic acid are important nutrients that have been included in fortified beverages and supplemental foods for pregnant and lactating women. While calcium has been shown to reduce the risk of pre-eclampsia and maternal mortality, calcium, phosphorus, potassium, magnesium and manganese can have negative impacts on organoleptic properties, so many products tested have not included these nutrients or have done so in a limited way. Fortified food supplements containing milk and essential fatty acids offer benefits to improving maternal status and pregnancy outcome. Fortified beverages containing only multiple micronutrients have been shown to reduce micronutrient deficiencies such as anaemia and iron deficiency.

Keywords: fortified food and beverage, pregnant and lactating women, nutritional status.

Introduction

The period of greatest risk and greatest opportunity for making a difference in children’s survival, growth and development is from conception through the first 2 years of life. These first 1000 days are when interventions can have long-term positive impacts on children’s survival, growth and intelligence quotient, resulting in improved school performance and higher incomes and enhanced productivity in adulthood.

Inadequate nutrition in pregnancy includes poor dietary quality and associated inadequate intakes of micronutrients, essential fatty acids, energy and protein resulting in low body mass and inadequate weight gain in pregnancy. This can lead to increased maternal mortality from severe anaemia and increased risk of pre-eclampsia, premature delivery and having a low-birthweight (LBW) baby.

Inadequate micronutrient intake is common in both non-pregnant non-lactating women (NPNL) and lactating women in developing countries. Figure 1 presents this data for Burkina Faso, Mali, Mozambique, Bangladesh and the Philippines. There is a high prevalence of inadequate intakes of riboflavin, niacin, folate, vitamin B12, calcium and iron among NPNL and low intake of almost all micronutrients for
lactating women across these five countries (Arimond et al. 2010). In Latin American countries and in other parts of the world, more than 40% of the population is at risk for inadequate zinc intake (Brown et al. 2004). Deficiencies in micronutrients such as vitamin B₁₂ in India and vitamin A in many parts of the world are common, and low intakes of other micronutrients (e.g. vitamins E and D and calcium) are also

**Key messages**

- Both micronutrient-fortified beverages and fortified supplementary foods, when given during pregnancy, have shown positive effects on maternal anaemia and iron deficiency prevention.
- Some studies have found that supplementary foods during pregnancy increased mean birthweight by around 60–73 g, which is about three times that seen with multiple micronutrient supplements.
- When both maternal nutritional status improvements and birth outcome improvements are the primary outcomes of a programme, fortified food supplements are preferable to fortified beverages containing only multiple micronutrients.
- Increasing intake of energy was related to improvements in birthweight but primarily in women who were more malnourished. High amounts of protein had no impact on birthweight. It is possible that ingredients such as milk, micronutrients or essential fatty acids had greater benefits on increasing mean birthweights. The interaction between milk ingredients, essential fatty acids and micronutrients warrants further investigation.

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**Fig. 1.** Prevalence of inadequate micronutrient intake of women in developing countries. The data were extracted from Table 6 (Arimond et al. 2010). NPNL, non-pregnant non-lactating women.
prevalent, compromising women's health and that of their newborns. In developing countries where dietary iron and zinc come primarily from plant-based sources, the bioavailability is low because anti-nutrients that are naturally present in plant-based foods can decrease the bioavailability of iron and zinc in these foods (Bhargava et al. 2001).

In developing countries, micronutrient deficiencies are common during pregnancy, and around 50% of pregnant women are anaemic. Severely anaemic women are at increased risk of death in pregnancy: 13% of maternal deaths in Asia and 4% in Africa are directly caused by anaemia (UNICEF, 2009). Anaemia contributes to the over 30% of deaths that are due to haemorrhage.

An assessment of micronutrient status among pregnant women in Nepal found that only 4% had no micronutrient deficiency and almost 18% had five or more deficiencies (Jiang et al. 2005). Nearly one-third (32%) of the women were deficient in riboflavin, 40% had vitamin B6 deficiency and 28% had vitamin B12 deficiency (Fig. 2).

Additionally, low intakes of essential fatty acids, especially omega-3 fatty acids, are problematic. While daily mean intakes of omega-3 fatty acids in pregnant women in the United States are 1470 mg (Nesheim & Yaktine 2007); in Chile (Mardones et al. 2008) and India (Muthayya et al. 2009), daily intakes in pregnant women are only one-third of that (500–600 mg). Such low intakes are related to low intake of fat and types of fats consumed (in developing countries, only soybean oil and rapeseed oil are commonly consumed oils that contains omega-3 fatty acids) and the fact that other foods containing omega-3 fatty acids (including fatty fish, meat and eggs) are not commonly eaten in sufficient amounts. In Burkina Faso, mean percent of energy as fat in the diet was only 13% in pregnant women (Huybregts et al. 2009b), and in Sudan and Bangladesh, fat intakes during lactation were only 19% (Nyuar et al. 2010) and 8% (Yakes 2010) compared with the minimum World Health Organization and US recommendation for pregnant and lactating women (20%).

Poor essential fatty acid status in pregnancy results in higher rates of LBW, pre-eclampsia and poor child development outcomes such as reduced visual acuity. Poor maternal fatty acid status in lactation results in low amounts of fatty acids in breast milk, which is associated with detriments to the infant's mental development and longer-term cognition (Eilander...
Poor maternal fatty acid status is also associated with post-partum depression (Eilander et al. 2007).

Numerous studies have shown the relationship between low energy intake, low body mass index (BMI) in pregnancy and inadequate weight gain with increased risk for LBW. Inadequate energy intake or poor quality diet are key risk factors for intrauterine growth restriction (IUGR) (Kramer & Kakuma 2003; Haider & Bhutta 2006) and other pregnancy complications (e.g. pre-eclampsia, Caesarean delivery) (Hofmeyr et al. 2011). LBW is also associated with increased risk of obesity and metabolic syndrome (i.e. insulin resistance) later in life, even after adjusting for adult BMI (Oken & Gillman 2003). In the developing world, the prevalence of LBW is about 16% and more than 10% of LBW babies exhibit IUGR (Black et al. 2008). Premature birth is another consequence of inadequate maternal nutrition, and 85% of the 10 million premature births are IUGR. LBW is an underlying factor in 60–80% of neonatal deaths (Lawn et al. 2010).

Maternal underweight (low BMI) is still prevalent in certain regions such as south-central Asia and sub-Saharan Africa (Black et al. 2008). Using Demographic and Health Survey data, rates of low BMI in women in developing countries range from less than 1% in Egypt to almost 40% in India. In Africa, the prevalence of maternal underweight is above 20% in Chad (22.6%), Ethiopia (23.8%) and Madagascar, (28.2%) and the highest rates are found in South Asia (India 39.9%, Bangladesh 32.8%, Nepal 26.1%).

Nutritional interventions have shown significant beneficial effects in reducing iron deficiency anaemia, neural tube defects, IUGR and pre-eclampsia during pregnancy and lactation (Kramer & Kakuma 2003; Haider & Bhutta 2006; Hofmeyr et al. 2011). Iron-folic acid supplements or multiple micronutrient supplements (MMS) during pregnancy have been recommended to improve micronutrient status and prevent neural tube defects (when given prior to pregnancy and in the first few weeks gestation). However, the coverage of these supplementation programmes has been low due to weak or ineffective policies, poor distribution, or lack of supplies, and the timing is usually too late to catch early pregnancy. For these and other reasons, anaemia during pregnancy is still highly prevalent (Kardjati et al. 1988; Black et al. 2008).

Improving dietary intakes of nutrients and essential fatty acids during pregnancy by counselling mothers on increasing intake of animal-source foods, fruits and vegetables, legumes and nuts, milk products, and fats/oils is an optimal approach, but might be difficult where such food availability is limited or costly. It is especially difficult to meet the additional iron needs during pregnancy through a dietary approach, unless foods such as meat, liver or blood are available and affordable. Foods specially formulated to meet the nutrient needs of pregnant and lactating women can help women meet their iron and other nutrient needs. However, in developing countries, there are few products specifically for pregnant or lactating women that are affordable or available in the market.

UNICEF’s Tracking Progress on Maternal and Child Nutrition (UNICEF 2009) emphasizes supplementation with iron–folic acid (Fe FA) or multiple MMS to reduce anaemia and other deficiencies prior to and during pregnancy. They suggest reducing anaemia to decrease pregnancy complications, maternal mortality and LBW and improving pregnant women’s micronutrient status through use of supplements and fortified foods in order to reduce micronutrient deficiencies. Additionally, they support the use of fortified food supplements [such as lipid-based nutrient supplements (LNS)] for undernourished women.

A recent meta-analysis summarized the results of 12 randomized clinical trials which provided approximately one recommended dietary allowance (RDA) of multiple micronutrients (MMNs) [nine of them used the United Nations International Multiple Micronutrient Preparation (UNIMMAP)] to pregnant women in developing countries. The results showed that overall, MMN supplementation increased mean birthweight by 22 g, compared with the control (mainly iron + folic acid supplements), reduced the prevalence of LBW and small-for-gestational age by 11% and 10%, respectively (Fall et al. 2009).
reviews also support these findings for MMNs (Haider & Bhutta 2006).

A Cochrane review also illustrated the benefits of calcium supplementation in pregnancy on reducing pre-eclampsia, death and serious morbidity (Hofmeyr et al. 2011). The Lancet series on maternal and child nutrition calculated that universal calcium supplementation (at least 1000 mg calcium per day) could prevent some 21 500 maternal deaths and reduce disability adjusted life-years by 620 000. Randomized controlled trials assessed intakes of supplements of fish oil, eicosapentaenoic acid and docosahexaenoic acid (DHA), or DHA alone (in supplements or eggs) in pregnancy in relation to pregnancy outcomes. Supplementation increased maternal DHA levels, placental transfer to the fetus (Helland et al. 2001; Dunstan et al. 2004; Krauss-Etschmann et al. 2007) and DHA concentration in breast milk (Imhoff-Kunsch et al. 2009). The dosage of DHA in these studies ranged from 0.4 g to 2.2 g.

Duration of gestation in the DHA supplementation group increased by 1.6–6.0 days in industrialized countries (Smuts et al. 2003; Makrides et al. 2009; Szajewska et al. 2006). DHA was associated with reduced risk of very early preterm birth (<34 weeks) in a meta-analysis of women at high risk for this (Horvath et al. 2007). The concentration of DHA has been shown to vary widely in breast milk, and thus consuming supplements that contain DHA could improve DHA breast milk concentration and the infant’s DHA status. Observational studies in both developed and developing countries indicate a likely relationship between DHA levels (as measured in breast milk) and post-partum depression, with lower levels of DHA associated with higher rates of post-partum depression (Hibbeln 2002).

In Mexico, Ramakrishnan et al. (2010) assessed the impact of DHA supplementation (400 mg/day) during pregnancy on infant growth and development through a randomized controlled intervention trial. Overall, no effect was found on growth outcomes (although cord and plasma DHA improved); however, among a subgroup of primigravidae, birth-weight significantly increased by 99.4 g and head circumference by 0.5 cm among the supplemented women.

The aim of this review is to identify vitamin- and mineral-fortified products developed specifically for pregnant and lactating women and examine their impacts on maternal nutritional status and growth, birth outcomes, and development of the offspring. We identified and assessed micronutrient fortified beverages (Latham et al. 2003; Hyder et al. 2007), products containing cow’s milk (Lechtig et al. 1975; Mora et al. 1979; Viegas et al. 1982a; Compbell-Brown 1983; Ross et al. 1985; Mardones-Santander et al. 1988; Atton & Watney 1990; Mardones et al. 2008; Fernald et al. 2009), high-fat products (Girija et al. 1984; Prentice et al. 1987; Ceesay et al. 1997) including LNS (Huybregts et al. 2009a) and protein-energy drinks (Rush et al. 1980; Adair & Pollitt 1985; Kardjati et al. 1988). This document can serve as a resource for developing nutrition products for pregnant or lactating women and provides concrete examples of fortified products that have shown impact on mothers or their offspring.

**Micronutrient fortified beverages (not containing milk or other protein/fat sources)**

In this review, a micronutrient fortified beverage is defined as a MMN-fortified drink with some added sugar, but without added protein or fat. Proctor and Gamble produced a fortified juice powder (25 g added to water and drunk twice daily), which was used in a trial in Tanzania. The nutrient composition is listed in Table 1 (Latham et al. 2003). The Tanzanian trial was a placebo-controlled, randomized clinical trial that started in 1999. Four hundred thirty-nine (439) pregnant women between 12 and 34 weeks of pregnancy were randomly assigned to either the experimental group (n = 227) or control group (n = 212) for 8 weeks. At follow-up, 127 pregnant women remained in the experimental group (44% dropout) and 132 pregnant women in the control group (38% dropout). Of those who completed the study, 93.4% consumed at least 70% of the supplements. At the end of the supplementation period, the prevalence of anaemia was significantly lower in the fortified beverage group (37%) than in the non-fortified group (48.5%) (P = 0.018), and serum ferritin concentrations were also significantly higher in...


<table>
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<tr>
<th>Nutrients</th>
<th>Fortified beverages in Tanzania (per day) (Latham et al. 2003)</th>
<th>Fortified beverages in Bangladesh (one serving) (Hyder et al. 2007)</th>
<th>UNIMMAP (daily dose) (Kaestel et al. 2005)</th>
<th>RNI WHO/FAO (2004) for pregnant women</th>
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<tr>
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the experimental group (21.5 μg L⁻¹) than in the control group (16.9 μg L⁻¹) \((P = 0.009)\). There were no significant differences in retinol or C-reactive protein concentrations between the two groups (Makola et al. 2003).

A similar product was evaluated in a randomized controlled trial in Bangladeshi adolescent girls (Hyder et al. 2007). The product was also produced by Proctor and Gamble with modifications to fit this younger age group. The nutrient composition is shown in Table 1. In the study, the fortified beverage had significant impacts on haemoglobin concentration, serum ferritin and retinol concentrations. However, the impact on serum zinc was not significant \((13.3\ vs. 12.9 \text{ μmol L}⁻¹, \ P = 0.3)\). Interestingly, the girls in the experimental group gained more weight and increased their mid-upper arm circumference compared with the girls in the control group.

In summary, these randomized controlled trials showed that MMN-fortified beverages significantly increased haemoglobin concentration \((-4 \text{ g L}⁻¹, \ P < 0.05)\) and ferritin concentrations \((-5-10 \text{ g L}⁻¹, \ P < 0.01)\), and reduced anaemia by approximately one-third \((P < 0.05)\) in pregnant women and adolescent girls. The MMN-fortified beverage significantly reduced vitamin A deficiency in adolescent girls \((P < 0.01, \text{Table } 2)\).

The daily dose of the MMN-fortified beverage for pregnant women contained 176 kcal with about 50% of the recommended nutrient intake (RNI) for iron, niacin, folic acid, iodine, and 100% of the RNI for vitamins A, E, B₁, B₆ and zinc, and 200% of the RNI for vitamins C and B₁₂.

### Products containing cow’s milk

A long-term prospective study, which lasted from 1969 to 1977 investigated the effect of energy-protein supplementation during pregnancy on birthweight in Guatemala (Lechtig et al. 1975). The study was a cluster randomized trial. Four villages were selected from qualified villages based on socio-economic status. Two villages (one small and one large) were given Atole (an energy-protein supplement). The matched two villages were given Fresco (a control product). Atole contained a vegetable protein mix
more than birthweights for those whose mothers con-

this pregnancy (20 000 kcal) was 246 g significantly

Fresco group (2992 g, higher in the

have existed. The mean birthweight was significantly

received the products. Thus, self-selection bias could

(mid-morning and mid-afternoon) (Martorell

in

phorus in

nacin), except for 400 mg calcium and 300 mg phos-

ments (either

mothers consumed a high intake of the supple-

showed that birthweight for the second child whose

pregnancies and interim lactation period. Results

weight gains (Table 4).

breastfed for a longer duration than those with lower

period. Women who gained more weight in pregnancy

larger infants instead of increasing their own weight

during this same period. Women who gained more weight in pregnancy

breastfed for a longer duration than those with lower

weight gains (Table 4).

Data were analysed from women who participated

in the supplementation trial during two consecutive

pregnancies and interim lactation period. Results

showed that birthweight for the second child whose

mothers consumed a high intake of the supple-

ments (either Atole or Fresco), during lactation

(>40 000 kcal), during the previous pregnancy and

this pregnancy (>20 000 kcal) was 246 g significantly

more than birthweights for those whose mothers con-

sumed lesser amounts of the supplements during the
course of the previous pregnancy (<20 000 kcal), lac-
tation (<40 000 kcal) and the most-recent pregnancy
(<20 000 kcal) (P < 0.025) (Villar & Rivera 1988).

A product studied in Chile among pregnant women

was a milk powder fortified with amino-chelated iron,

omega-3 fatty acids (0.9 g alpha-linolenic acid and

4.4 g linoleic acid/100 g product) and additional

micronutrients (Mardones et al. 2008). The nutrient

composition of the product is listed in Table 3. This

was a randomized controlled trial without blinding of

subjects but the investigators were blinded.

The study started in 2002 and an iron-folic acid

supplementation programme during pregnancy was

already in place with high coverage. Women received

2 kg of powdered milk each month (about 67 g per
day). Powdered milk fortified with smaller amounts of

iron (ferrous sulfate), zinc, vitamin C and other nutri-

ents was used as a control. The main difference

between these two products was that the more highly

fortified milk powder contained higher amounts of

energy (521 kcal vs. 498 kcal per 100 g), vitamins,

trace minerals and essential fatty acids. Vitamins A, C,

E, B6, niacin, biotin, folic acid, magnesium and sele-

nium were much lower in the control group.

In this study in Chile, underweight pregnant

women (BMI < 21.2 kg m−2, at the 10th week of preg-
nancy) were randomly allocated to the treatment

group (n = 589) or control group (n = 552) before 20

weeks of gestation. The mean gestational age at enrol-

ment was 11.36 weeks for the intervention group and

10.66 weeks for the control group (P < 0.05), and the

treatment lasted until delivery (about 30 weeks for

the intervention). The reason participants in the

experimental group had, on average, a higher mean

gestational age at enrolment was due to unintended

late distribution of the fortified milk used for the

intervention.

The mean daily consumption of the two supple-

ments was slightly higher in the control group (36.9 ±

26.2 g day−1–185 kcal day−1) than in the experi-

mental group (31.2 ± 31.0 g day−1–163 kcal day−1).

The primary outcomes were birthweight and gesta-

tional age. Based on intention-to-treat analysis, mean

birthweight was significantly higher (65 g) in the treat-

ment group (3265 g) than in the control group (3200 g)
Table 3. Nutrient composition of products containing cow’s milk.

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<tr>
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IU, International Units; PUFA, polyunsaturated fatty acid; RNI, recommended nutrient intake. *Food and Nutrition Board, (2002/2005); energy is calculated for a low active pregnant woman aged 30 years in the second trimester with a body mass index of 18.5 kg/m² and height 1.55 m (Food and Nutrition Board, 2002), from dietary recommended intakes females 19–50 years. †From Food and Agriculture Organization/IAEA/World Health Organization, trace elements in human nutrition and health (1996). ‡Assume moderate bioavailability of zinc during the third trimester.
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<th>Site</th>
<th>Study design</th>
<th>Subjects</th>
<th>Study group</th>
<th>Control group</th>
<th>Intake</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lechtig (Lechtig et al. 1975)</td>
<td>Guatemala</td>
<td>Cluster RCT and the village was matched in socioeconomic status and population size</td>
<td>All pregnant women living in the villages, voluntarily participating in the supplementation trial</td>
<td>Atole with 59 kcal energy and no protein with same level fortificants except Ca and P</td>
<td>Fresco</td>
<td>Median intake was 163 kcal daily for about 4 months</td>
<td>Significant effects of Atole on birthweight (3107 g vs. 2992 g); High intake also significant improved birthweight (3105 g vs. 2994)</td>
</tr>
<tr>
<td>Mardones (Mardones et al. 2008)</td>
<td>Chile</td>
<td>RCT without blinding</td>
<td>Pregnant women before 20 weeks</td>
<td>Milk powder fortified with ALA and more micronutrients</td>
<td>Milk powder fortified with small amount of micronutrients</td>
<td>32 g milk powder with about 170 kcal energy</td>
<td>Significant increase in birthweight (3265 g vs. 3200 g), birth length (49.36 cm vs. 48.98 cm), and decrease in very early preterm delivery (0.4% vs. 2.1%). Significant improvements in birthweight (3778 g vs. 3105 g), IUGR (0.25% vs. 40.7%), haemoglobin (126 g L⁻¹ vs. 119 g L⁻¹), iron deficiency (45% vs. 73%)</td>
</tr>
<tr>
<td>Mardones-Santander (Mardones-Santander et al. 1988)</td>
<td>Chile</td>
<td>RCT without blinding</td>
<td>Underweight pregnant women before 20 weeks of pregnancy</td>
<td>Fortified milk powder</td>
<td>Milk powder without fortification</td>
<td>37 g milk powder with 174 kcal</td>
<td>Significant improvement in birthweight (3178 g vs. 3105 g), IUGR (32.5% vs. 43.7%), haemoglobin (126 g L⁻¹ vs. 119 g L⁻¹), iron deficiency (45% vs. 73%)</td>
</tr>
<tr>
<td>Barber (Barber &amp; Gertler 2008)</td>
<td>Mexico</td>
<td>Quasi-experimental design</td>
<td>Eligible pregnant women (condition on economical status for cash transfer)</td>
<td>Fortified milk-based supplements</td>
<td>Delayed receiving supplements</td>
<td>52 g per daily ration contained 250 kcal</td>
<td>Significant improvement in birthweight (127 g), reducing in LBW by 4%. No significant difference in birthweight, significantly improved maternal skin fold thickness</td>
</tr>
<tr>
<td>Viegas (Viegas et al. 1982b)</td>
<td>UK</td>
<td>RCT</td>
<td>Pregnant women starting at 18–20 weeks of gestation</td>
<td>Fortified skimmed milk</td>
<td>Vitamin or energy-vitamin supplements</td>
<td>Chocolate flavoured milk drink with 273 kcal energy daily from 18–38 weeks</td>
<td>No significant difference in birthweight (3550 g vs. 3020 g in vitamin control)</td>
</tr>
<tr>
<td>Viegas (Viegas et al. 1982a)</td>
<td>UK</td>
<td>RCT</td>
<td>Selected pregnant women with skinfold thickness increment &lt;20 μm week⁻¹ from 18–28 and the treatment lasted from 28–38 weeks</td>
<td>Skimmed milk with multivitamin and energy-vitamin supplements</td>
<td>Multivitamin or energy-vitamin supplements</td>
<td>Chocolate flavoured milk drink with 450 kcal energy daily from 28–38 weeks</td>
<td>Significant improvement in birthweight</td>
</tr>
<tr>
<td>Atton (Atton &amp; Warner 1998)</td>
<td>UK</td>
<td>RCT</td>
<td>Selected pregnant women with skinfold thickness increment &lt;20 μm week⁻¹ from 18–28 and the treatment lasted from 28–38 weeks</td>
<td>Fortified skimmed flavoured milk</td>
<td>No supplement</td>
<td>Milk drink with 407 kcal energy and 146 g protein</td>
<td>No significant difference in birthweight</td>
</tr>
</tbody>
</table>

IUGR, intrauterine growth restriction; LBW, low-birthweight; RCT, randomized controlled trial.
Mean birth length was also significantly greater (0.38 cm) in the treatment group (49.36 cm) than in the control group (48.98 cm) \( (P = 0.019) \). Maternal weight gain during pregnancy was 500 g higher in the treatment group than in the control group (14.5 kg vs. 14.0 kg), but the difference was not significant. Gestational duration was slightly longer in the treatment group (~1.4 days). They also found decreases in very early preterm births (0.4% vs. 2.1%, \( P = 0.02 \)) and marginal decreases in pre-eclampsia (1.6% vs. 3.4%, \( P = 0.083 \)).

Additionally, on-treatment analysis was conducted because the experimental food arrived after the study began and women who did not receive the treatment as allocated during the 3 months were excluded. The on-treatment analyses showed statistically significantly larger increases in birthweight (118 g), birth length (0.57 cm) and head circumference (0.20 cm). They also found decreases in pre-eclampsia (15% vs. 6%). The national food distribution programme for low-income pregnant women in Chile now includes milk fortified with essential fatty acids.

An earlier trial in Chile conducted in 1983 used fortified milk powder as well (Mardones-Santander et al. 1988). This product contained higher amounts of iron (43 mg vs. 27 mg) and vitamin C (340 mg vs. 110 mg), and less protein (14.5 g vs. 25 g) than the one described earlier, and no alpha-linolenic acid was included in the product (Table 3). This study was also a randomized controlled trial. Underweight pregnant women before 20 weeks of gestation (mean gestational age ~14.5 weeks) were randomly assigned to the treatment group \( (n = 570) \) or the control group \( (n = 565) \). The intervention lasted ~25 weeks until delivery and the mean intake of the fortified product was 37 g day\(^{-1}\). The subjects in the control group received unfortified milk powder. At the end of the study, mean birthweight was significantly higher (72 g) in the treatment group \( (3178 \text{ g}, n = 391) \) than in the control group \( (3105 \text{ g}, n = 391) \), and the percentage of IUGR infants was significantly lower in the treatment group (32.5%) than in the control group (43.7%) \( (P < 0.05) \). In a sub-study, mean haemoglobin concentration was significantly higher in the fortified group \( (126 \text{ g L}^{-1}, n = 68) \) than in the control group \( (119 \text{ g L}^{-1}, n = 71) \), and the prevalence of low ferritin concentrations was significantly lower in the fortified group (45%) than in the control group (73%). Pregnancy weight gain was significantly higher (1 kg) in the experimental group (12.3 kg) than in the control group (11.3 kg) \( (P < 0.05) \), as was early post-partum weight loss \( (P < 0.05) \).

The Mexican government started a poverty alleviation programme in 1997, which is now called Oportunidades (formerly Progresa) (Rivera et al. 2000). This programme is a conditional cash transfer (CCT) programme with strong nutritional components. In addition to a CCT, children 6–48 months with weight-for-age Z-scores <-1 and pregnant and lactating women all received milk-based fortified foods (Rivera et al. 2000). The formulation of the supplements for pregnant women is listed in Table 3 (Rosado et al. 2000). The pudding-like product contained 250 kcal per serving and was fortified with several nutrients, including iron and zinc. A quasi-experimental study design was used to evaluate the programme. Communities were randomly assigned into either early start of the programme (320 communities) or delayed (18 months later) initiation of the programme (186 communities). Several studies found that growth outcomes, development and behaviour outcomes were positively associated with the CCT programme (Barber & Gertler 2008; Fernald et al. 2008; Leroy et al. 2008; Fernald et al. 2009). One study showed that birthweight was 127 g higher among the women who received the benefits of the CCT programme than those who did not. Additionally, the prevalence of LBW was reduced by 4% for the women who received benefits, compared with those who did not (Barber & Gertler 2008).

Another study on the Oportunidades programme reported that on average after 2 years, children younger than 6 months at baseline grew 1.5 cm and 0.76 kg more in the beneficiary families than those in the control families, which may be due to those mothers accepting benefits through the whole pregnancy and early lactation period (Leroy et al. 2008). Another possibility could be that younger children were more sensitive to infant and young child nutrition intervention. Doubling cash transfers was also associated with greater height-for-age Z-score (HAZ), low prevalence of stunting, and better motor development.
and cognitive development (Fernald et al. 2008). Even though it is not possible to attribute the higher birthweight among women who received the fortified nutrient supplements during pregnancy solely to these supplements, fortified supplements during pregnancy appear to have played an important role.

A study in the United Kingdom in 1979 assessed the impacts of flavoured milks on birthweight (Viegas et al. 1982b). Pregnant women at 18 weeks of gestation were randomly assigned into one of three groups: (1) vitamin and mineral; (2) energy, vitamin and mineral; and (3) protein, energy, vitamin and mineral for about 38 weeks. The nutrient composition is listed in Table 3. There were no significant mean differences in birthweight (all roughly 3.0 kg) among the groups.

In a subsequent study (Viegas et al. 1982a), the same products with multiple vitamin supplements were selectively given to pregnant women with a low mean increase in triceps skinfold thickness <$0.2 mm month$^{-1}$ (average of the increase between 18 and 28 weeks). The results showed that protein energy and multi-vitamin supplementation significantly increased birthweight by 330 g (3350 g vs. 3020 g) and increased skinfold thickness in those whose mean triceps skinfold thickness measurements were <$0.2 mm month$^{-1}$. However, for those women whose mean triceps skinfold thickness increased >$0.2 mm month$$^{-1}$ between 18–28 weeks, there was no effect.

In the 1980s, a different flavoured milk drink was selectively provided to UK pregnant women with small changes ($\leq$0.2 mm) in triceps skinfold thickness between 18–28 weeks of pregnancy (Atton & Watney 1990). The nutrient composition is listed in Table 3. Briefly, the product contained 158 kcal and 5.7 g protein per 100 mL with a low level of micronutrients (about 10% of the RDA, except for phosphorus, which was 16%). This was a randomized controlled trial with a non-intervention normal control group, which was defined as changes in mean triceps skinfold thickness between 18–28 weeks >$0.2$ mm. Those pregnant women with small increments in triceps skinfold thickness (<$0.2$ mm) were randomly assigned into either a supplement group or control group. The normal control group continued not receiving supplements. There were no significant benefits detected among any of the groups.

A milk-based porridge (100 g dry milk, ~72 g maize flour, containing 699 kcal per day) or a bean-corn blended food [bean and maize (1.2:1) mush containing 775 kcal] was offered to pregnant women in South Africa in 1977 in a randomized controlled trial (Ross et al. 1985). Pregnant women before 20 weeks of gestation were recruited and randomly assigned into one of the four groups (placebo supplement, 30–90 mg zinc gluconate supplements, bean-corn blended food and milk-based food). The supplements were provided until delivery. These products contained calcium, iron, vitamin A, niacin, riboflavin and thiamine. The nutrient composition is listed in Table 3. Mean birthweight was significantly higher in the milk-based product group (3376 g) than in the other three groups (placebo: 3171 g, zinc: 3088 g, bean-corn blended food: 3082 g) ($P < 0.05$).

In a Vietnamese study among 84 pregnant women, consumption of fortified milk (400 ml, 120 calories, 6.8 g protein, 15 mg elemental iron, 200 µg folic acid and 17.5 mg vitamin C) was compared with unfortified milk, and a supplement containing 60 mg Fe250 µg of folic acid and a placebo supplement. The risk of developing anaemia after 16 weeks intervention was lowest in the groups who received iron (fortified milk and iron supplement groups), and the prevalence of achieving adequate weight gain was greatest in the milk groups. The highest weight increases were found in the fortified and non-fortified milk groups (5.8 ± 2.1 and 5.0 ± 2.0 kg, respectively), followed by the supplemented group (4.6 ± 3.1 kg) and the placebo group (3.8 ± 2.5 kg). The authors state:

The distribution of fortified milk to pregnant women is far more expensive than the distribution of iron (sic) supplements alone. However, in the Vietnamese situation, in which mothers have a high prevalence of acute undernutrition, supplementation alone was insufficient to address weight gains during pregnancy. Rather, the increased availability of fortified food commodities such as milk at the household level should be considered. (Hoa et al. 2005)

In a randomized controlled trial in the 1970s in Colombia, pregnant women in the first or second trimester were randomly assigned to supplementation

or control groups (Mora et al. 1979). The supplements included dry skim milk, enriched bread, vegetable oil and vitamin/mineral supplements, which contained 856 kcal, 38.4 g protein, 6024 IU vitamin A and 18 mg iron. The results showed that subjects in the supplementation group increased their mean daily energy intake by 155 kcal and mean protein intake by 20 g. Mean birthweight was significantly higher for full-term male newborns in the supplementation group (3061 g) than in the control group (2966 g), but this was not observed for their female counterparts (2935 g vs. 2942 g). Male offspring may be more sensitive to nutrition supplements as shown in other studies (Adair & Pollitt 1985).

In addition to studies or programmes that have tested products that contain cow’s milk, several studies have assessed programmes which provided milk as part of the food package for pregnant women. In another UK study in the 1970s, pregnant women at risk for undernutrition (defined as weight-for-height at 20 weeks of gestation or weight gain below the 25th percentile of the Aberdeen reference for women) were randomly assigned into a food supplementation group or a control group (Campbell-Brown 1983). The food supplements included a flavoured milk drink, fresh milk or cheddar cheese, which provided 299 kcal and 15.9 g protein on average. There were no significant differences in birthweight (3032 g vs. 2995 g), gestational age (39.7 weeks vs. 39.6 weeks), or maternal weight gain during the 30 weeks of intervention (0.4 kg week\(^{-1}\) vs. 0.36 kg week\(^{-1}\)) between treatment group and control group.

In the United States, the Special Supplemental Food Program for Women, Infants and Children (WIC) provides food supplements for pregnant and lactating women. The foods provided include milk, cheese, eggs, iron-fortified cereal and fruit juice, which are intended to improve iron, vitamin A and vitamin C intake. An early evaluation by Kennedy et al. found that the birthweight of WIC participants’ offspring was about 60 g higher than those who did not participate in WIC, after controlling for total weight gain during pregnancy, gestational age, pregravid weight and prior history of LBW (Kennedy et al. 1982). Haemoglobin concentration and haematocrit were also significantly improved by 4 g L\(^{-1}\) and 1.3%, respectively, in the WIC participants compared with non-participants (Kennedy & Gershoff 1982).

An evaluation that used a sibling model to estimate the effectiveness of the WIC programme on birthweight showed that mean birthweight was about 185 g higher for children whose mothers participated in the WIC programme than their siblings whose mothers did not participate (Kowaleski-Jones & Duncan 2002). Another study evaluated the effects of postpartum supplementation (5–7 months vs. 0–2 months) on the subsequent pregnancy outcome in a WIC population in California. The study showed that mean birthweight (131 g) and mean birth length (0.3 cm) were significantly greater and LBW rate was significantly lower in the treatment group (5–7 months) than in the control group (0–2 months) (Caan et al. 1987). The current contents of the WIC food package are shown in Fig. 3 [United States Department of Agriculture (USDA 2007)]. State agencies determine which specific foods are allowed in the package. However, the federal government has specifications that must be met for fortification levels. These foods and their fortification levels may help in determining appropriate foods for pregnant women in developing countries, where normal food intake is often less and the quality worse than among poor women in the United States. According to US federal requirements, milk must be fortified and contain at least 400 IU of vitamin D per quart (100 IU per cup) and 2000 IU of vitamin A per quart (500 IU per cup). Soy-based beverages must be fortified to meet the following nutrient levels per cup: 276 mg calcium, 8 g protein, 500 IU vitamin A, 100 IU vitamin D, 24 mg magnesium, 222 mg phosphorus, 349 mg potassium, 0.44 mg riboflavin, and 1.1 mcg vitamin B\(_12\), in accordance with fortification guidelines issued by the Food and Drug Administration; juice must be pasteurized, 100% unsweetened fruit juice and must contain at least 30 mg of vitamin C per 100 mL of juice; breakfast cereals must contain a minimum of 28 mg iron per 100 g dry cereal and contain \(\leq 21.2\) g sucrose and other sugars per 100 g dry cereal (\(\leq 6\) g per dry oz). Canned fish can include light tuna, salmon, sardines and mackerel (USDA 2007).

In summary, eight out of a total of 11 studies that measured birthweight showed that fortified products...
containing cow’s milk significantly improved birthweight (Table 4). The magnitude of the improvement in birthweight ranged from 60 to 330 g. The beneficial effects were seen in three out of five studies where malnourished subjects (defined as underweight or maternal skinfold thickness increment during 18–28 weeks <0.2 mm week⁻¹) were investigated.

Two studies reported significant increases in haemoglobin ranging from 4 to 7 g L⁻¹. In addition, there were significant improvements in birth length, very early pre-term delivery or iron deficiency reported in the Chile studies (Mardones-Santander et al. 1988; Mardones et al. 2008).

Because various control groups were used in different studies, the causal effects could be attributed to MMN, dairy components, essential fatty acids or all of these components. The interaction between MMN and dairy components was not evaluated in these studies, thus an interaction effect cannot be ruled out.

Fortified high-fat products

High-fat products are defined in this review as products in which more than 35% of energy is provided by fat. A study by Prentice et al. provided groundnut-based biscuits and vitamin-fortified tea to pregnant women in the Gambia (Prentice et al. 1987). The nutrient compositions of the fortified supplements are listed in Table 5. The fortification level for calcium, riboflavin, and vitamins A and C was between 18% and 42% of the RNI for 100 g of biscuits (each biscuit contained 546 kcal) and 100 g of tea. 47 mg iron as ferrous sulfate and 500 μg folic acid were provided to every pregnant woman. A maximum of three biscuits and 380 g tea in the dry season and a maximum of four biscuits and 380 g tea in the hungry season were provided daily, containing 1209 kcal and 1513 kcal, respectively. This study used a historical control.

The mean birthweight of babies born during the 4-year supplementation (1980–1984...
<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Gambia Biscuits with tea per 100 g (Prentice et al. 1987)</th>
<th>Gambia Biscuits per serving (Prentice et al. 1980)</th>
<th>UNILITO (fortified corn-soy blend) (daily dose) (Shrimpton et al. 2009)</th>
<th>LNS-soy (Burkina Faso) per daily serving (72 g) (Kaesestel et al. 2005)</th>
<th>RNI WHO/FAO (2004) for pregnant women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount % of RNIs</td>
<td>Amount % of RNIs</td>
<td>Amount % of RNIs</td>
<td>Amount % of RNIs</td>
<td>Amount % of RNIs</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>546 25</td>
<td>1015 46</td>
<td>455 21</td>
<td>372 17</td>
<td>2200*</td>
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<tr>
<td>Protein (g)</td>
<td>20.3 29</td>
<td>22 31</td>
<td>13.4 19</td>
<td>14.7 21</td>
<td>71*</td>
</tr>
<tr>
<td>Fats (g)</td>
<td>27.1 56</td>
<td>56</td>
<td>24.9</td>
<td>27.6</td>
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<td>Saturated fat</td>
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<tr>
<td>MUFA</td>
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<td>n-3 PUFA</td>
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<tr>
<td>n-6 PUFA</td>
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<tr>
<td>Carbohydrates (g)</td>
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<td>Lactose (g)</td>
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<tr>
<td>Vitamin A (IU)</td>
<td>1132 42</td>
<td>1665 63</td>
<td>2986 110</td>
<td>2664</td>
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<td>Vitamin D3 (μg)</td>
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<td>Vitamin E (mg)</td>
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<tr>
<td>Thiamin (mg)</td>
<td>0.4 29</td>
<td>0.2 14</td>
<td>5.6 31</td>
<td>21 117</td>
<td>18</td>
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<tr>
<td>Riboflavin (mg)</td>
<td>0.47 34</td>
<td>0.2 14</td>
<td>5.6 31</td>
<td>21 117</td>
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<tr>
<td>Niacin (mg)</td>
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<td>0.2 14</td>
<td>5.6 31</td>
<td>21 117</td>
<td>18</td>
</tr>
<tr>
<td>Vitamin B6 (mg)</td>
<td>0.47 34</td>
<td>0.2 14</td>
<td>5.6 31</td>
<td>21 117</td>
<td>18</td>
</tr>
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<td>Vitamin B12 (μg)</td>
<td>2.6 100</td>
<td>2.6 100</td>
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<td>Pantothenic acid (mg)</td>
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<td>Ascorbic acid (mg)</td>
<td>10 18</td>
<td>40 73</td>
<td>71 129</td>
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<td>47 4</td>
<td>130 7</td>
<td>90 8</td>
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<td>Potassium (mg)</td>
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<td>Magnesium (mg)</td>
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<tr>
<td>Iron (mg)</td>
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<td>7.2 27</td>
<td>17 17</td>
<td>17 17</td>
<td>10‡</td>
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<td>Zinc (mg)</td>
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<td>200‡</td>
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<td>Copper (mg)</td>
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<td>1.15†</td>
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<td>Manganese (mg)</td>
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<td>Iodine (μg)</td>
<td>150 75</td>
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<td>Selenium (μg)</td>
<td></td>
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</tbody>
</table>

IU, International Unit; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; RNI, recommended nutrient intake. *Food and Nutrition Board, (2002/2005); energy is calculated for a low active pregnant woman aged 30 years in the second trimester with a body mass index of 18.5 kg/m² and height 1.55 m (Food and Nutrition Board, 2002) females 19–50 years. †From Food and Agriculture Organization/IAEA/WHO, Trace elements in human nutrition and health (1996). ‡Assume moderate bioavailability of zinc during the third trimester.
post-supplementation) was compared with that of babies born 4 years immediately before the study (1976–1980 pre-supplementation). The mean duration of supplementation was 24 weeks and the mean intake of supplements was about 671 kcal day⁻¹, which was about 44–55% of those provided. After adjusting for sex, parity, month and gestational age, mean birthweight was significantly higher (200 g) in post-supplementation (3010 g) than in pre-supplementation (2810 g) during the wet (hungry) season. However, the difference was not significant during the dry season (2959 g vs. 2972 g; pre-supplementation vs. post-supplementation, respectively). LBW was also less common in post-supplementation than in pre-supplementation during the wet season. Supplementation had no significant effect on maternal weight gain during pregnancy. No significant difference was detected for gestational age between pre- and post-supplementation groups.

A similar biscuit with some modifications (e.g. calcium density was decreased to 46 mg 1000 kcal⁻¹ from 384 mg 1000 kcal⁻¹ in the previous product) was tested again in the Gambia in 1989 by using a cluster randomization trial (Ceesay et al. 1997). Two biscuits contained 4250 kJ (1015 kcal, 507.5 kcal per biscuit) energy, 22 g protein, 56 g fat, 47 mg calcium and 1.8 mg iron. They contained roasted groundnuts, rice flour, sugar and groundnut oil and therefore, though high in fat, contained no good source of omega-3 fatty acids. The study found that the food supplements increased birthweight by 201 g in the hungry season and by 94 g in the dry season (harvest season). The supplementation also increased head circumference by 3.1 mm. The odds of LBW, stillbirths and all deaths during the first week of life were reduced by 39%, 53% and 46%, respectively (Table 6).

A similar biscuit containing wheat-soy flour, dried skimmed milk, groundnut oil and tea was mentioned previously in the Gambian studies was also offered to lactating women in the Gambia (Prentice et al. 1980). The historical controls were used in the study. The supplements were given for 12 months and the mean energy intake from the supplements was 830 kcal day⁻¹. The breast milk volume was similar between pre- and post-supplementation groups. The fat content of breast milk also did not differ between women who were supplemented and those who were not supplemented during the pre-supplementation period (3.94 g dl⁻¹ vs. 3.86 g dl⁻¹; pre- vs. post-supplementation, respectively). Women in the supplement group were heavier than those in the pre-supplementation group at the same calendar month at the same duration post-partum.

A small-scale randomized controlled trial (n = 10 for each group) was conducted in the early 1980s in India (Girija et al. 1984). Normal dietary intake met 60% of pregnant women’s RNI for energy. The trial provided 50 g of sesame cake, 40 g of jaggery (molas-ses) and 10 g of oil (30 g protein and 417 kcal) to the treatment group in the third trimester of pregnancy. The results showed that haemoglobin levels increased significantly in the treatment group compared with the control group (19.7 g L⁻¹ vs. 1.7 g L⁻¹). Mean daily breast milk production was significantly higher in the treatment group (465 g) than in the control group (158 g) but mean birthweight and birth length in the two groups were not statistically significant (but sample sizes were quite small).

In refugee camps housing Bhutanese in Nepal, an 11% decrease in the prevalence of LBW and an increase in mean birthweight from 2.84 kg to 3.0 kg were associated with micronutrient-dense foods (Shrimpton et al. 2009). A fortified corn-soy blended food and added oil, containing 455 kcal per day, called UNILITO, was provided to pregnant women throughout. The nutrient composition is listed in Table 5.

LNS have been suggested for use during pregnancy (Briend 2001). They contain high amounts of fat, including a good source of omega-3 fatty acids, in a small amount of food (such as a fortified peanut paste containing canola or soy oil, sugar, micronutrients and sometimes milk). A recently completed trial in Burkina Faso assessed the impact of LNS on birth outcomes (Huybregts et al. 2009a). Pregnant women (n = 1300) were randomly assigned into either an LNS group (370 kcal, 72 g) daily with UNIMMAP micronutrient formulation (Table 6) or a control group (UNIMMAP tablet). The results showed that birth length was 0.5 cm significantly greater (P = 0.001) and placental weight (15 g) was significantly heavier in the
### Table 6. Impacts of high-fat products on nutritional status

<table>
<thead>
<tr>
<th>Author</th>
<th>Site</th>
<th>Study design</th>
<th>Subjects</th>
<th>Study group</th>
<th>Control group</th>
<th>Intake</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prentice</td>
<td>Gambia</td>
<td>Historical control</td>
<td>All pregnant women in catchments area</td>
<td>Fortified biscuits and tea</td>
<td>Un-supplemented</td>
<td>Daily intake about 671 kcal</td>
<td>Significant improvement in birthweight (3010 g vs. 2810 g) in hungry season; no effect in dry season (2972 g vs. 2959 g).</td>
</tr>
<tr>
<td>Ceesay</td>
<td>Gambia</td>
<td>Cluster-randomization</td>
<td>Pregnant women from 20 weeks of gestation</td>
<td>Biscuits containing 101.5 kcal energy, 22 g protein and 56 g fat.</td>
<td>Un-supplemented</td>
<td>The maximum intake was two biscuits</td>
<td>Significant increase in birthweight by 201 g in hungry season, but not in harvest season; head circumference in 3.1 mm; reducing odds of stillbirth and all death by 53% and 46%, respectively.</td>
</tr>
<tr>
<td>Huybregts</td>
<td>Burkina Faso</td>
<td>RCT</td>
<td>Pregnant women starting from first trimester and some second trimester</td>
<td>LNS fortified with 1 RNI MMN as UNIMMAP</td>
<td>UNIMMAP</td>
<td>72 g LNS (372 kcal, 14.7 g protein, 27.6 g fat,</td>
<td>No significant difference in birthweight; Significantly greater birth length (4.6 mm longer in LNS group) and placental weight (15.6 g heavier) in LNS group.</td>
</tr>
</tbody>
</table>

LNS, Lipid-based nutrient supplement; MMN, multiple micronutrient; RCT, randomized controlled trial; RNI, recommended nutrient intake; UNIMMAP, United Nations International Multiple Micronutrient Preparation.
LNS group (579 g) than in the control group (564 g) \( (P = 0.04) \), but there was no effect on birthweight. Maternal nutritional status, haemoglobin concentration, and gravidity modified the effects of the LNS. Effects on birth length were significant for mothers who were multigravida, had low BMI or anaemia compared with their counterparts not receiving LNS. Among women who had BMI <18.5, the mean increase in height of newborns was 1.2 cm \( (P = 0.005) \), and the placental weight increased by 56 g \( (P = 0.017) \). The increase in birthweight was 111 g \( (P = 0.13) \), though non-significant perhaps because of low numbers of very malnourished women. The treatment did not affect preterm delivery.

In summary, high-fat products had significant impacts on birth outcomes (i.e. birthweight in the Gambia and Nepal studies, and birth length in the Burkina Faso study) (Table 6). The increase in birthweight was greater in the hungry season (~200 g) than in the harvest season (13–94 g) in the Gambia studies. Micronutrient status is expected to be comparable in both the Gambia and Burkina Faso study due to similar micronutrient consumption between treatment and control.

The energy intake from these products was more than 350 kcal per day. Fat provided >40% of the energy in these products. Although the omega-3 fatty acid content of the foods used in the Gambia was low due to the use of groundnuts and groundnut oil, the LNS in Burkina Faso was developed to have significant amounts of omega-3 fatty acids, through the inclusion of full fat soy flour.

**Formulated protein-energy drinks**

In this review, a formulated protein-energy drink is defined as a protein-containing beverage with or without micronutrient fortification that does not use milk as a key ingredient. These were tested out over 20 years ago, before an understanding of the need for essential fatty acids was wide-spread. At that time, protein was considered to be a limiting element in developing country diets. However as will be shown, protein was found not to be a major concern and in fact high intakes appear to be detrimental to pregnancy outcomes.

A chocolate-flavored energy and nutrient-rich liquid supplement containing 400 kcal per serving was used during pregnancy and lactation in a study in Taiwan, China (Adair & Pollitt 1985). The nutrient composition is listed in Table 7. The fortification level for most micronutrients was close to one RNI. A few micronutrients were fortified at <50% of the RNI, including vitamin E and iron. The study was a double-blinded randomized controlled trial. Pregnant women were randomly assigned to a treatment group \( (n = 114) \) or placebo group \( (n = 111) \). The intervention started 3 weeks after the birth of the first born child and continued until 15 months of lactation for the second born child. The liquid supplements provided two servings per day (12.5 oz per serving). In addition to receiving either the intervention product or placebo, multi-vitamin and mineral supplements were provided to both groups. The main outcomes were birthweight and birth length. There were no significant treatment effects on birthweight or birth length. Birthweight was slightly higher (56 g, 31.7 g) for both sexes in the treatment group (M: 3216.0 g, F: 3012.5 g) than in the control group (M: 3160.6 g, F: 2980.8 g), respectively. Due to the low power of the study, these differences were not statistically significant. Within the treatment group, birthweight was significantly higher in the male babies born after the second pregnancy with treatment (3216.0 g) than in the male babies born after the first pregnancy without treatment (3053.6 g) \( (P = 0.013) \). The mean Bayley motor development score was not significantly different between the treatment group (3.8, \( n = 99 \)) and the control group (3.31, \( n = 99 \)) \( (P = 0.058) \) but sample sizes were small. Maternal haematocrits were significantly higher in the treatment group (35.3%) than in the control group (33.0%) and than in the pre-treatment (33.7%) at 2 months before delivery \( (P < 0.05) \).

A randomized controlled trial in Indonesia in 1982 measured the impacts of a protein-energy beverage containing palm oil and sunflower oil (both low in omega-3 fatty acids), high or low amounts of casein and glucose without micronutrient fortification during pregnancy on birthweight and breast milk output (Kardjati et al. 1988; van Steenbergen et al. 1989). The nutrient composition is listed in Table 7. Pregnant women in the third trimester were randomly assigned...
Table 7. Nutrient composition of formulated protein-energy drink

<table>
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<tbody>
<tr>
<td></td>
<td>Amount</td>
<td>% of RNIs</td>
<td>Amount</td>
<td>% of RNIs</td>
<td>Amount</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>400</td>
<td>18</td>
<td>465</td>
<td>21</td>
<td>470</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>20</td>
<td>28</td>
<td>7.1</td>
<td>10</td>
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<tr>
<td>Fats (g)</td>
<td>13.3</td>
<td>25.8</td>
<td>8.6</td>
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<td>Milk fat</td>
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<td></td>
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<tr>
<td>Vegetable fat</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n-3 PUFA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n-6 PUFA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Carbohydrates (g)</td>
<td>50</td>
<td>29</td>
<td>46.5</td>
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<td>Fiber (g)</td>
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<td>Lactose (g)</td>
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<tr>
<td>Vitamin A (IU)</td>
<td>2500</td>
<td>94</td>
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<tr>
<td>Vitamin D3 (μg)</td>
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<td>100</td>
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</tr>
<tr>
<td>Vitamin E (mg)</td>
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<td>22</td>
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<tr>
<td>Thiamin (mg)</td>
<td>0.8</td>
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<tr>
<td>Riboflavin (mg)</td>
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<tr>
<td>Niacin (mg)</td>
<td>10</td>
<td>56</td>
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<tr>
<td>Vitamin B6 (mg)</td>
<td>0.8</td>
<td>42</td>
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<tr>
<td>Folic acid (μg)</td>
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<td></td>
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<tr>
<td>Vitamin B12 (μg)</td>
<td>1.0</td>
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<tr>
<td>Pantothenic acid (mg)</td>
<td>3.68</td>
<td>61</td>
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<tr>
<td>Ascorbic acid (mg)</td>
<td>37.5</td>
<td>68</td>
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<tr>
<td>Biotin (μg)</td>
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<td>Sodium (mg)</td>
<td>200</td>
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<tr>
<td>Potassium (mg)</td>
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<tr>
<td>Phosphorus (mg)</td>
<td>400</td>
<td>57</td>
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<tr>
<td>Magnesium (mg)</td>
<td>6.0</td>
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<td></td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>138†</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>4</td>
<td>40</td>
<td>0.084</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>0.5</td>
<td>43</td>
<td>0.15</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Manganese (mg)</td>
<td>1.0</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine (μg)</td>
<td>150</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IU, International Unit; RNI, recommended nutrient intake. †Food and Nutrition Board, (2002/2005), energy is calculated for a low active pregnant woman aged 30 years in the second trimester with a body mass index of 18.5 kg/m² and height 1.55 m (Food and Nutrition Board, 2002) females 19–50 years. §From Food and Agriculture Organization/IAEA/WHO, Trace elements in human nutrition and health (1996). ‡Assume moderate bioavailability of zinc during the third trimester.
to either a high energy or low energy group. The high-energy beverage contained 465 kcal and 7.1 g protein per 200 ml; the low energy beverage contained 52 kcal and 6.2 g protein per 200 ml. There was no significant difference in birthweight (2908 g vs. 2948 g, high energy vs. low energy groups, respectively), or breast milk production between these two supplement groups. However the children born to the high energy group were taller and stunting rates were lower throughout the first 5 years (Kusin et al. 1992). Material weight gain was not statistically different between the two groups (7.1 kg vs. 6.4 kg; treatment \(n=272\) vs. control \(n=265\), respectively).

A fortified protein-energy drink was tested in the 1970s in New York (Rush et al. 1980). Pregnant women \(n=1051\) were randomly assigned to one of three groups (supplement, complement and control groups). The supplement group received 40 g casein and 470 kcal and the complement group received 6 g casein and 322 kcal. The control group received multivitamin-mineral supplements, which were at the same dosage as in the complement group. The detailed nutrient content is listed in Table 7. The supplements continued until delivery. At delivery, 770 pregnant women remained in the study and delivered singleton births. There were no significant effects of treatment on birthweight. The complement group had a slightly higher birthweight (41 g) than the control group (which may reflect the impact of the casein, a milk product); however, this was not statistically significant. Early premature delivery and neonatal death were associated with high protein supplementation. The supplement group with high protein content had a significantly lower birthweight than complement group or control group for premature delivered infants \(<37\) weeks). Children in the supplement group showed better visual habituation (a type of non-associative learning), visual dishabitation (recovery of attention), and mean length of free play episode at 1 year of age.

In summary, these randomized controlled trials showed that protein and energy administered without other nutrients had no significant beneficial effects on birthweight (Table 8), no matter when [pre-pregnancy (Adair & Pollitt 1985) or mid-pregnancy (Rush et al. 1980)] the protein-energy drinks were given. Learning capabilities were improved in one study when receiving the high protein-energy supplement (Rush et al. 1980; Haider & Bhutta 2006). The high protein supplements were associated with some adverse effects (pre-mature delivery, premature-related neonatal death and LBW) (Rush et al. 1980). Maternal haematocrit was improved in one study (Adair & Pollitt 1985).

These protein-energy products contained 233–552 kcal energy with 7–30 g protein daily. The control groups received multi-vitamin and mineral supplements with a similar formulation as the treatment group received through the supplement (Adair & Pollitt 1985; Kardjati et al. 1988) or the fortified product (Rush et al. 1980; Ross et al. 1985). The potential benefits of micronutrients could not be detected because of lack of a placebo control.

### Discussion

Both micronutrient-fortified beverages and fortified supplementary foods, when given during pregnancy, have shown positive effects on maternal anaemia and iron deficiency prevention. For example, anaemia prevalence was reduced by approximately one-third in fortified beverage studies in Tanzania, and haemoglobin concentration increased by 4–7 g L\(^{-1}\) in the Tanzania study and in the earlier fortified milk powder study in Chile.

Some studies have found that supplementary foods during pregnancy increased mean birthweight by around 60–73 g, which is about three times that seen with MMS. Under certain circumstances (e.g. during the hungry season in the Gambia, in women from 18–28 weeks of gestation with smaller increases in skinfold thickness), the supplement led to an increase in mean birthweight of 115–330 g. Both macronutrients and micronutrients contributed to the positive changes, but the level of maternal nutritional status, birthweight and sex of offspring modified the effects of treatments.

High fat supplements consumed during pregnancy were associated with desirable outcomes assessing birth length, placental weight, very-early preterm delivery, pre-eclampsia and IUGR, stillbirth and neonatal mortality. For example, in two studies where essential fatty acids were provided, birth length was
Table 8. Impacts of formulated protein-energy drink

<table>
<thead>
<tr>
<th>Author</th>
<th>Site</th>
<th>Study design</th>
<th>Subjects</th>
<th>Study group</th>
<th>Control group</th>
<th>Intake</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adair (Adair &amp; Pollitt 1985)</td>
<td>Taiwan, China</td>
<td>Placebo-controlled, double-blinded RCT (multivitamin mineral supplements provided to both groups)</td>
<td>Women 3 weeks after first birth through first lactation, second pregnancy and second lactation (15 months)</td>
<td>Chocolate flavoured nutrient dense drink (400 kcal per serving)</td>
<td>Placebo drink (3 kcal before 06/1971 and 43 kcal after, per serving)</td>
<td>17 oz</td>
<td>Significantly heavier in post-treatment than in pre-treatment for male babies (3216 g vs. 3054 g); maternal haematocrits significantly greater (35.3% vs. 33%)</td>
</tr>
<tr>
<td>Kardjati (Kardjati et al. 1988)</td>
<td>Indonesia</td>
<td>RCT</td>
<td>Women at 26–28 weeks of gestation</td>
<td>High-energy drink (465 kcal per serving) 'jamu'</td>
<td>Low-energy drink (52 kcal per serving, 6.2 g protein)</td>
<td>200 mL (465 kcal, 7.1 g protein)</td>
<td>No significant effects</td>
</tr>
<tr>
<td>Rush (Rush et al. 1980)</td>
<td>New York, USA</td>
<td>RCT with stratification</td>
<td>Women &lt;30 weeks of gestation</td>
<td>Fortified protein-energy drink (473 kcal with 40 g casein)</td>
<td>Low protein-energy drink (322 kcal and 6 g casein) or MMN supplements</td>
<td>473 mL (326/470 kcal from the treatment, 233/322 kcal from the complement drink)</td>
<td>No significant effects on birthweight; for heavy smokers, supplements had effects to prevent birthweight deficit; high protein supplement significantly increased very early premature delivery and neonatal death (3.2% vs. 1.1%); and improved visual habituation, visual dishabituation, and the mean length of free play episodes</td>
</tr>
</tbody>
</table>

MMN, multiple micronutrient; RCT, randomized controlled trial.
0.4–0.5 cm greater in the treatment group than in the control group (Mardones et al. 2008; Huybregts et al. 2009a).

Maternal food supplementation during pregnancy was not related to maternal weight gain during pregnancy in the majority of studies, but was when maternal weights were low at start.

Increasing intake of energy was related to improvements in birthweight but primarily in women who were more malnourished. High amounts of protein had no impact on birthweight. It is possible that ingredients such as milk, micronutrients or essential fatty acids had greater benefits on increasing mean birthweights. The interaction between milk ingredients, essential fatty acids and micronutrients warrants further investigation.

A fortified beverage can improve the status of other important micronutrients such as vitamin A in addition to improving iron status. Fortified food supplementation during pregnancy positively affected the offspring’s learning capability during childhood.

Given the experiences mentioned and summarized up to this point, products to be consumed during pregnancy and lactation could be formulated to improve either maternal micronutrient status or birth outcomes. A question, however, is whether women are more likely to consume a beverage instead of a tablet or capsule, especially if the cost is higher. Because many women’s diets in developing countries are low in omega-3 fatty acids, and also because milk consumption is often minimal, it may be more appropriate to develop products containing these ingredients to benefit the mother and subsequently her offspring.

Iron, zinc, copper, iodine, selenium, vitamins A, D, E, C, B1, B2, B6, B12, folic acid, niacin and pantothenic acid are important nutrients for both fortified beverages and supplemental foods. Calcium, phosphorus, potassium, magnesium and manganese may have negative impacts on organoleptic properties, but these nutrients are important and may be needed if missing in local diets. Calcium has been shown to reduce the risk of pre-eclampsia and maternal mortality (Hofmeyr et al. 2011). The fortification levels used previously were generally between 50–100% of the RNI. Decisions on nutrients to include and their levels should be based on the dietary intake of the target population and the characteristics of the product.

When both maternal nutritional status improvements and birth outcome improvements are the primary outcomes of a programme, fortified food supplements are preferable to beverages containing only MMN.

Products containing milk and oils higher in omega-3 fatty acids such as soy or canola oil showed more beneficial impacts, but further studies are needed to test these specific ingredients. When food insecurity is not an issue to be addressed, the daily energy intake from the product could be at the level of 100–300 kcal to avoid energy over-consumption. If food insecurity is a problem, additional energy could be added, a high percentage (>35%) of which can come from fat. This type of product should include micronutrients such as calcium, potassium, phosphorus, magnesium and manganese (either from the food itself or from fortificants) because they are more easily added to a food supplement. The level of essential fatty acids (e.g. ALA – linolenic acid) needs to be tested in food-based products (for example, the level consumed in Chile was about 0.4 g daily) to achieve better effects. No DHA was used in the fortified food supplements reported here. Based on the impacts of DHA supplementation studies, if DHA is used, 0.4 g DHA daily could be a starting point for fortification; however, costs of DHA might be prohibitive.

Acknowledgements

The author would like to thank Marie Chantal Messier (Senior Nutrition Specialist, World Bank), and Jonathan Siekmann, Senior Associate, Infant and Young Child Nutrition (GAIN), and Elizabeth Zehner, for their valuable review, technical input and contributions. Support from GAIN enabled the author to produce the paper and make it available for the benefit of all those working to improve maternal and infant and young child nutrition. Chinese National High-tech R&D Program (863 programme no. 2010AA023004) partially supported the work.

Conflicts of interest

No conflicts of interest exist.
References


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Essential fats: how do they affect growth and development of infants and young children in developing countries? A literature review

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Abstract

Omega-3 and omega-6 fatty acids, particularly docosahexaenoic acid (DHA), are known to play an essential role in the development of the brain and retina. Intakes in pregnancy and early life affect growth and cognitive performance later in childhood. However, total fat intake, alpha-linolenic acid (ALA) and DHA intakes are often low among pregnant and lactating women, infants and young children in developing countries. As breast milk is one of the best sources of ALA and DHA, breastfed infants are less likely to be at risk of insufficient intakes than those not breastfed. Enhancing intake of ALA through plant food products (soy beans and oil, canola oil, and foods containing these products such as lipid-based nutrient supplements) has been shown to be feasible. However, because of the low conversion rates of ALA to DHA, it may be more efficient to increase DHA status through increasing fish consumption or DHA fortification, but these approaches may be more costly. In addition, breastfeeding up to 2 years and beyond is recommended to ensure an adequate essential fat intake in early life. Data from developing countries have shown that a higher omega-3 fatty acid intake or supplementation during pregnancy may result in small improvements in birthweight, length and gestational age based on two randomized controlled trials and one cross-sectional study. More rigorous randomized controlled trials are needed to confirm this effect. Limited data from developing countries suggest that ALA or DHA supplementation during lactation and in infants may be beneficial for growth and development of young children 6–24 months of age in these settings. These benefits are more pronounced in undernourished children. However, there is no evidence for improvements in growth following omega-3 fatty acid supplementation in children >2 years of age.

Keywords: essential fatty acids, omega-3 and omega-6 fatty acids, growth, development, ALA, DHA, developing countries.

Introduction

The omega-3 fatty acid alpha-linolenic acid (ALA) and the omega-6 fatty acid linoleic acid (LA) are essential fatty acids (EFAs) as they can not be produced by the human body. Oils/seeds that contain the largest amounts of ALA include flaxseed, walnut, beechnut, butternuts, chia seeds, canola and soy. Oils such as corn, sunflower, palm and peanut oil are high in LA but low in ALA. Meat is also a good source of ALA and LA (Institute of Medicine 2005).

The omega-6 fatty acid LA can be converted into longer chain metabolites, including arachidonic acid (AA) and the omega-3 fatty acid ALA can be
converted into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (see Fig. 1 for an overview of this process). However, the conversion rates are low with a range from 1% to 10% (Emken et al. 1994; Salem, Jr. et al. 1999; Vermunt et al. 1999; Pawlosky et al. 2001; Brenna 2002) and may differ depending on common polymorphisms in the fatty acid desaturase (FADS) gene cluster which enables some individuals to form more EPA, DHA and AA from ALA and LA than others (Lattka et al. 2010a,b). Conversion rates are lower in infants (especially premature infants) than adults and there is accumulating evidence that in early life, precursors are not sufficiently converted to DHA to allow for biochemical and functional normality (Uauy & Castillo 2003; Innis 2007b; Uauy & Dangour 2009).

**Key messages**

- Omega-3 and omega-6 fatty acids play an important role in growth and development of infants and young children in developing and emerging countries.
- Overall, intakes of fat and omega-3 fatty acids appear to be low among many pregnant and lactating women, and non-breasted infants. Most complementary foods are low in omega-3 fatty acids, and thus young children in developing countries are at risk of low intakes.
- Ensuring adequate intakes of fat, essential fatty acids and especially DHA through these life stages is crucial.
- Cost effective dietary sources of these fatty acids and exclusive breastfeeding until 6 months of age, and continued breastfeeding thereafter, in addition to appropriate complementary feeding are needed to ensure adequate essential fatty acid and DHA intakes in these populations.
- Information is severely lacking on essential fatty acid intake and status in developing countries, and data should be collected from large-scale studies such as the Demographic and Health surveys or other nationally representative samples.
- In addition, more research is required to confirm the beneficial role of these essential fatty acids from diets or from supplements in growth and development of infants and young children in developing countries.
There is currently no general agreement as to whether EPA + DHA and AA are essential in the diet. Only animal products and algae contain DHA and EPA, and fatty fish (tuna, salmon, fish oils), eggs and algae are good sources. Breast milk contains LA, ALA, DHA and EPA although the amounts depend on the mother’s diet and fat stores (Brenna et al. 2007; Peng et al. 2009). Cow’s milk contains no DHA or EPA, and is low in ALA and LA. AA can be found in meat, poultry and eggs (Institute of Medicine 2005).

Populations consuming low amounts or no animal foods will depend to a large extent or completely on the synthesis of EPA + DHA and AA by the human body. This situation applies to many people living in developing countries, who cannot afford significant quantities of animal foods. Sufficient intakes of LA and ALA are needed, but when energy (especially fat) intakes are low, LA and ALA would be preferentially used for energy expenditure rather than conversion to AA and EPA + DHA (Food and Nutrition Board 2007). Thus, a combination of low intakes of animal foods, total fat and insufficient energy results in developing country populations being more at risk of inadequate EFA intake.

Furthermore, iron, zinc, vitamin B6 and vitamin E are required for the conversion of ALA and LA to EPA + DHA and AA through their role in elongation enzymes (Smuts et al. 1994). Therefore, it is possible that micronutrient deficient populations may have a lower conversion rate than well-nourished populations and may therefore have a lower status of EPA + DHA and AA (Smuts et al. 1994).

EFAs (LA and ALA) and their long-chain derivatives (EPA, DHA and AA) are important for numerous physiological and developmental needs of humans. For example, the brain is composed of large amounts of both DHA and AA. During the third trimester of pregnancy and first year of life, the brain grows rapidly and an adequate supply of both of these fatty acids is thought to be essential for optimal development (Innis 2007a; Hoffman et al. 2009). DHA is also a major component of the retina and thus affects visual acuity (Hoffman et al. 2009). AA and DHA are vital structural elements of cell membranes and, therefore, instrumental in the formation of new tissues. In addition, PUFAs affect growth through their role in synthesis of prostaglandins, growth hormones and biosynthesis of membrane components (Gurr 1992; Root 1992). A clinical deficiency of ALA or LA results in neurological abnormalities and poor growth (Institute of Medicine 2005).

Emerging evidence is suggestive of other possible benefits of omega-3 fatty acids during pregnancy, including a possible role in prevention of pregnancy complications such as pre-eclampsia and maternal depression. A prospective study in Pune, India compared pre-eclamptic women with normotensive women recruited after 35 weeks gestation and found plasma DHA and plasma and RBC total omega-3 FA levels to be significantly lower in the pre-eclamptic group, while omega-6 FA were higher (Mehendale et al. 2008). Observational studies in both developed and developing countries indicate a likely relationship between DHA levels (as measured in breast milk) and postpartum depression, with lower levels of DHA associated with higher rates of postpartum depression (Hibbeln 2002). Maternal depression can impact maternal care-giving abilities and affect growth through inadequate feeding practices and development through poor interpersonal interactions (Patel et al. 2004).

In addition, there is emerging evidence that omega-3 fatty acid intakes in pregnancy and early life may play a role in prevention of diseases mediated by eicosanoids (van Eijden et al. 2008; Hauner et al. 2009). In particular EFA intakes are thought to modify low-density lipoproteins (LDL) cholesterol concentrations in childhood (Ohlund et al. 2008). Most of the data, however, came from observations in developed countries and in formula fed infants and little is known about the public health relevance of these fatty acids for infants in developing countries, especially those who still receive breast milk.

This paper reviews the literature on omega-3 and omega-6 fatty acid intake and status in pregnant and lactating women and infants and young children in developing countries and evaluates the effects of these fatty acids on growth and development of infants and children in these countries. The findings are compared with those of studies in developed countries. A recent supplement to this journal reported on papers presented at a meeting on fatty acids in pregnancy.
acids in developing countries (Dewey & Reinhart 2011).

**Methods**

For identification of studies, we searched the literature databases of Web of Science (Institute for Scientific Information) and PubMed (omega 3 fatty acids OR essential fatty acids OR DHA OR docosahexaenoic acid OR long-chain polyunsaturated fatty acid OR n-3 fatty acid OR arachidonic acid OR linoleic acid AND child development OR infant development OR child growth OR infant growth). The search was limited to human studies published in English from January 2000 until August 2010. The search first identified meta-analyses and clinical trials, but was expanded to include other relevant articles (such as observational studies and review articles). Reference lists of the publications found were also searched. From these lists, articles that were conducted in developing countries were selected for inclusion in this review.

We adopted the income definition of developing countries used by The World Bank to include countries in the review. The definition includes all countries having an annual gross national income (GNI) per capita equivalent to US$ 12,195 or less; these countries include low-income countries (GNI per capita up to US$ 995), lower middle-income countries (GNI per capita from US$996–$3,945) and upper middle-income countries (GNI per capita from US$3946 to $12,195) (World Bank 2010).

**Recommended fatty acids intake for pregnant, lactating women, infants and children**

The minimum intake levels for EFAs to prevent deficiency symptoms are estimated with convincing evidence from human and animal studies at level to be 2.5%E LA plus 0.5%E ALA (FAO 2010). The adequate intake (AI) is a recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by group (or groups) of apparently healthy people who are assumed to be maintaining an adequate nutritional state. Examples of adequate nutritional states include normal growth, maintenance of normal levels of nutrients in plasma and other aspects of nutritional well-being or general health. When an RDA is not available for a nutrient, the AI can be used as the guide for an individual’s intake (Institute of Medicine 2005). An AI for LA of 2–3%E and ALA of >0.5%E is proposed for the general population of adults by Food and Agriculture Organization (FAO), with an acceptable macronutrient distribution range (AMDR) for LA intake of 2.5–9%E and omega-3 PUFA of 0.5–2%E. For infants 6 to 12 months of and young children 12–24 months of age, an AI for LA range of 3.0–4.5%E is recommended with a (upper) U-AMDR of <10%. Similarly for ALA an AI range of 0.4–0.6%E is recommended with (upper) U-AMDR of <3%E (FAO 2010).

Table 1 gives AI for ALA and LA from FAO (2010) and from the Institute of Medicine (2005). Recommended levels of DHA in pregnancy are shown from FAO (2010) (Brenna & Lapillonne 2009) and the European Consensus Group (Koletzko et al. 2007). For pregnant and lactating women, the minimum intake for fetal and infant development is 300 mg/day EPA + DHA, of which at least 200 mg day$^{-1}$ should be DHA (FAO 2010). For infants, recommendations for omega-3 and omega-6 intakes are based on the composition of human milk, under the provision that after 6 months, human milk meets half of the daily energy needs (FAO 2010).

For assessment of the effects of EFAs and omega-3 fatty acids and child growth and development in developing countries, we divided the literature into four topics:

1. Dietary intake and status of total fat, LA, ALA and DHA in pregnancy, lactation, infants and young children in developing countries.
2. Fatty acids intake during pregnancy and effects on infant growth and development.
3. Fatty acids intake during lactation and effects on infant growth and development.
4. Supplementation of infants (0–24 months of age) with fatty acids and effects on growth and development.

<table>
<thead>
<tr>
<th>Total fat</th>
<th>ALA (AI)</th>
<th>LA (AI)</th>
<th>ALA mg day$^{-1}$ (AI)</th>
<th>LA g day$^{-1}$ (AI)</th>
<th>Ratio of LA to ALA</th>
<th>DHA mg day$^{-1}$</th>
<th>DHA + EPA (AI) mg day$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute of Medicine 2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 months</td>
<td>500</td>
<td>4.4</td>
<td>5–15:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7–12 months</td>
<td>500</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–3 years</td>
<td>30–40%</td>
<td>0.6–1.2% E</td>
<td>5–10% E</td>
<td>700</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 years</td>
<td>25–35%</td>
<td>0.6–1.2% E</td>
<td>5–10% E</td>
<td>900</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td>1400</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactation</td>
<td>1300</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>20–35%</td>
<td>0.6–1.2% E</td>
<td>5–10% E</td>
<td>Varies by age</td>
<td>Varies by age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAO (2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 months</td>
<td>40–60% E</td>
<td>AI 0.2–0.3% E*</td>
<td>breast milk composition as %E of total fat</td>
<td>AI 0.1–0.18% E*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6–24 months</td>
<td>35% E</td>
<td>AI 0.4–0.6% E</td>
<td>AI 3.0–4.5% E</td>
<td>AI 10–12 mg kg$^{-1}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–4 years</td>
<td>25–35% E</td>
<td>AI ≥ 0.5% E*</td>
<td>AI 2–3 %E**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 years</td>
<td>AI ≥ 0.5% E*</td>
<td>AI 2–3 %E**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6–10 years</td>
<td>AI ≥ 0.5% E*</td>
<td>AI 2–3 %E**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy/lactation</td>
<td>20–35% E</td>
<td>≥0.5% E</td>
<td>2–3% E</td>
<td>200</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>European consensus group (Koletzko et al. 2007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ALΑ, alpha-linolenic acid; AI, Adequate intake; DHA, docosahexaenoic acid; LA, linoleic acid; EPA, eicosapentaenoic acid. *Food and Agriculture Organization (FAO 2010) recommendations do not specify ranges for 2–18 years olds, so the adult levels are shown here. *For children 6–24 months of age the estimation of requirements is based on provision of breast milk to meet half of the daily energy needs, the rest of the energy would come from non-breast milk diet (FAO 2010). **Same as adults, considering pregnant and lactating women’s energy intake will increase hence fat and fatty acids in absolute amount will increase as well.
5. Supplementation of children >2 years of age with fatty acids and effects on growth and development.

Results

Dietary intake and status of total fat, LA, ALA and DHA in pregnancy, lactation, infants and young children in developing countries

Dietary intake of total fat and fatty acids in pregnancy and lactation

A range of 20–35% energy as total fat during pregnancy and lactation has been suggested by FAO (Brenna et al. 2007; FAO). Intake data on total fat in pregnant women were found from six developing countries namely Bangladesh, Burkina Faso, Chile, China, India and Mexico (Table 2). In all these countries, total fat intakes were within the AMDRs in pregnant and lactating women in studies in Chile, China, India and Mexico but not in Bangladesh, Burkina Faso and Sudan. In these countries, pregnant and lactating women consumed diets with only 7.6%E (Yakes 2010), 12.7%E (Huybregts et al. 2009) and 18.5 E% (Nyuar et al. 2010) of total fat, respectively.

In studies in India (Muthayya et al. 2009a), Chile (Mardones et al. 2008), Mexico (Parra-Cabrera et al. 2010), Sudan (Nyuar et al. 2010), Bangladesh (Yakes 2010), among pregnant or lactating women, mean intakes of ALA just met or were lower than the AI (Table 2). In contrast, LA intakes exceeded the AI in most countries except Bangladesh (Table 2). In Bangladesh, 57% of the women had intakes of LA below the AI and 90% had ALA below the AI (Yakes 2010). The low intake of ALA in certain populations and high intakes of LA compared with the AI may be in part due to consumption of oils in local diets that are high in LA but low in ALA such as corn, safflower, sunflower oil and to some extent peanut, palm kernel and coconut oil (Wolmarans 2009).

The lowest DHA intakes were reported in India in the third trimester of pregnancy at only 11 mg (Muthayya et al. 2009a) and in Bangladesh, DHA intake was only 30 mg per day (Table 2). All reported levels are substantially less than the FAO (Brenna et al. 2007; FAO 2010) recommends and European Consensus
(Koletzko *et al*. 2007) recommended amounts of 200 mg of DHA in pregnancy.

**DHA status data in lactation**

Breast milk DHA levels are one means of assessing essential fat status in lactating women. Breast milk DHA content has been associated with favourable infant outcomes: Innis (2007c) reports that maternal intakes of DHA \( \leq 80 \, \text{mg day}^{-1} \) and milk levels \(<0.2 \, \text{g DHA/100 g total fatty acids (0.2%)} \) increases the risk of not supporting optimal infant development (Innis 2007c).

The mean concentration of DHA in breast milk is quite variable in developing countries with data. Some developing countries such as Sudan 0.23%E (Nyuar *et al*. 2010), Nepal 0.23%E (Glew *et al*. 2001), Bangladesh 0.30%E (Yakes 2010) and Mexico (0.26 ± 0.03) (Yuhas *et al*. 2006) have reported some of the lower levels of DHA in breast milk whereas Philippines (0.74 ± 0.05), a coastal area of southeastern China (0.61 ± 0.46%E) (Peng *et al*. 2009), Cuba (0.43 ± 0.26) (Krasevec *et al*. 2002) and Chile (0.43 ± 0.03) (Yuhas *et al*. 2006) have reported higher DHA status of breast milk than several developed Western countries (Brenna *et al*. 2007) other than Japan (Yuhas *et al*. 2006).

The large range of DHA content in breast milk is thought to reflect mainly the variations in maternal DHA intake, as populations with high fish intakes also have the highest milk DHA content as is seen from a comparison of intakes in a study of women living in an inland (0.38 ± 0.23%E) or coastal area (0.61 ± 0.46%E) of southeastern China (Peng *et al*. 2009). In Congo where fish intake is high and the usual oil consumed is soy oil, which is rich in ALA (Rocquelin *et al*. 1998), breast milk contained a higher DHA content (0.15 ± 0.07 vs. 0.08 ± 0.05 g/100 g) than in Burkina Faso, where fish intake is low and the major oil sources are peanut and cotton seed oil, which are both low in ALA (Thiombiano-Coulibaly *et al*. 2003).

Overall, more information is needed on fatty acids intake and status in pregnant and lactating women from developing countries. LA intakes were generally higher than the AI in countries where reported except Bangladesh, whereas ALA intake is below the AI in all countries. Mean DHA intakes are less than recommended for optimal fetal development in pregnant women in all studies found. Milk DHA contents in most countries were at the low end, but were greater than 0.2%-the cutoff associated with suboptimal infant development.

**Dietary intake of total fat and fatty acids in infants and children (0–10 years)**

Dietary intake data of total fat and individual fatty acids in infants and young children were found in five countries. Total fat intakes in infants and young children in many developing countries, especially in infants who are not breastfed, are lower than the minimum recommended of 35%E at 6–24 months of age (Table 3). In Bangladesh, intakes were extremely low at 19.5%E in breastfed and only 12.7% in non-breastfed children at 24–35 months of age (Yakes 2010) whereas in children of 1–3 years of age in rural areas from Yunnan Province China, mean fat intake was 24 ± 7%E (Barbarich *et al*. 2006). In the Gambia, fat intake decreased from 46.2%E at 0–6 months (when most energy came from breast milk) to 34.4%E at 7–11 months, 27.5%E at 12–17 months and only 15%E when breastfeeding had stopped in most children at 24 months (Prentice & Paul 2000). In older children (2–10 years) total fat intake ranged from 24.5% to 29.6%E in Guatemala and South Africa.

Mean LA intakes were lower than the AI in Bangladeshi (non-breast fed) children and Chinese children (1–3 years). In other developing countries with data, children had mean LA intakes in the range of 3.1–6.2%E. Mean ALA intakes were lower than AI in Bangladesh, Gambian and South African children. In Yunnan, China, ALA intake among children 1–3 years of age for about 50% of children did not meet the AI (Barbarich *et al*. 2006). In rural Bangladesh, intakes of fatty acids among children 24–35 months of age were only reported in comparison with the Institute of Medicine (IOM) levels, and were approximately half of the IOM AI; 89.8% of these children had intakes of ALA less than the IOM AI of 700 mg day\(^{-1}\) for 1- to 3-year-old children, and 99.0% had intakes of LA less than the AI of 7 g day\(^{-1}\) for 1–3-year-olds. In the Gambia, levels of ALA and DHA
Table 3. Mean (standard deviation) intake of total fat, LA, ALA, DHA in the diet of infants and young children in developing countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Age group</th>
<th>Total fat intake (%E)</th>
<th>LA intake (%E)</th>
<th>ALA intake (%E)</th>
<th>DHA intake (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOM (Institute of Medicine) 2005</td>
<td>1–3 years</td>
<td>30–40%</td>
<td>5–10%E</td>
<td>0.6–12%E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4–18 years</td>
<td>25–35%E</td>
<td>5–10%E</td>
<td>0.6–12%E</td>
<td></td>
</tr>
<tr>
<td>FAO 2010</td>
<td>6–24 months</td>
<td>At least 35%</td>
<td>3–4.5%E</td>
<td>0.4–0.6%E</td>
<td>100 mg (ages 2–4 years)</td>
</tr>
<tr>
<td></td>
<td>2–18 years</td>
<td>25–35%</td>
<td>2–3% adults†</td>
<td>≥0.5% adults†</td>
<td></td>
</tr>
<tr>
<td>Bangladesh* (Yakes 2010)</td>
<td>Breastfed (24–35 months)</td>
<td>19.5 (10.5–30.1) %E</td>
<td>3.5 (1.7–6.3) %E</td>
<td>0.39 (0.29–0.60) %E</td>
<td>40 (10–80) mg</td>
</tr>
<tr>
<td></td>
<td>Non-breastfed (24–35 months)</td>
<td>12.7 (6.2–21.5)%E</td>
<td>2.9 (1.3–5.2) %E</td>
<td>0.42 (0.12–0.74) %E</td>
<td>10 (0–30) mg</td>
</tr>
<tr>
<td></td>
<td>Breastfed (36–48 months)</td>
<td>15.6 (7.8–26.9)%E</td>
<td>3.1 (1.3–5.8) %E</td>
<td>0.41 (0.18–0.76) %E</td>
<td>20 (10–30) mg</td>
</tr>
<tr>
<td></td>
<td>Non-breastfed (36–48 months)</td>
<td>11.8 (5.8–20.5) %E</td>
<td>2.8 (1.2–5.4) %E</td>
<td>0.39 (0.17–0.71) %E</td>
<td>20 (10–30) mg</td>
</tr>
<tr>
<td>China (Yunnan) (Barbarich et al. 2006)</td>
<td>1–3 years</td>
<td>24 ± 7%E</td>
<td>2.9 ± 1.2%E</td>
<td>0.4 ± 0.3%E</td>
<td>34 ± 148 mg</td>
</tr>
<tr>
<td>Gambia (Prentice &amp; Paul 2000)</td>
<td>0–6 months</td>
<td>46.2%E</td>
<td>6.0%E</td>
<td>0.38%E</td>
<td>108 mg</td>
</tr>
<tr>
<td></td>
<td>7–12 months</td>
<td>34.4%E</td>
<td>5.4%E</td>
<td>0.28%E</td>
<td>87 mg</td>
</tr>
<tr>
<td></td>
<td>12–17 months</td>
<td>27.5%E</td>
<td>5.1%E</td>
<td>0.23%E</td>
<td>75 mg</td>
</tr>
<tr>
<td></td>
<td>24 months</td>
<td>15.0%E</td>
<td>4.6%E</td>
<td>0.13%E</td>
<td>10 mg</td>
</tr>
<tr>
<td>Guatemala (Bermudez et al. 2010)</td>
<td>8–10 years (high income)</td>
<td>29.6 ± 0.42%E</td>
<td>5.3 ± 0.12%E</td>
<td>0.5 ± 0.01%E</td>
<td>32 ± 2 mg</td>
</tr>
<tr>
<td></td>
<td>8–10 years (low income)</td>
<td>28.6 ± 0.53%E</td>
<td>5.9 ± 0.14%E</td>
<td>0.5 ± 0.01%E</td>
<td>32 ± 2 mg</td>
</tr>
<tr>
<td>South Africa (Mangaung) (Dannhauser et al. 2000)</td>
<td>2–3.9 years</td>
<td>26.2 ± 15.1%E</td>
<td>6 ± 5.4%E</td>
<td>0.39 ± 0.5%E</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>4–5.9 years</td>
<td>24.5 ± 16.4%E</td>
<td>6.2 ± 5.9%E</td>
<td>0.27 ± 0.27%E</td>
<td>–</td>
</tr>
</tbody>
</table>

ALA, alpha-linolenic acid; DHA, docosahexaenoic acid; FAO, Food and Agriculture Organization; LA, linoleic acid. *Mean (5th–95th percentile). †FAO recommendations do not specify ranges for 2–18-year-olds, so the adult levels are shown here.
intake decreased as the child aged. In Mangaung (South Africa) the mean omega-6 intake ranged from 5.4% to 6.5% and omega-3 ranged from 0.2% to 0.4% in 2–6-year-old children (Dannhauser et al. 2000). Large proportions of 8–10 years old Guatemalan children had normal intakes of LA (5.3±0.12–5.9±0.14%E) in both high and low socioeconomic status whereas ALA intakes (0.5±0.01%E) were low with >97% of all groups consuming less than 1%E from these fats and about 50% consuming less than FAO AI ≥0.5%E. Furthermore, intakes for EPA (8±2–10±2 mg) and DHA (32±2 mg) were very low with no differences between high and low socioeconomic status groups (Bermudez et al. 2010).

In summary, in most developing countries with data available, mean intakes of ALA and DHA are very low and in two out of five countries with data available, mean LA intakes were below the AI.

**Fatty acid status data in infants and children**

Only two studies reported status data in infants and children from developing countries. Low DHA levels in RBC were reported in Pakistani infants in relation to the low DHA content in maternal milk (Smit et al. 2000). In an intervention study, baseline fatty acids status in 6 month-old Cambodian and Italian infants were compared. Cambodian infants had lower baseline levels of LA, comparable ALA levels and higher levels of AA + EPA + DHA in blood compared with their Italian counterparts (Agostoni et al. 2007). Subsequent multiple micronutrient supplementation in those Cambodian infants resulted in significantly higher levels of ALA in whole blood samples (0.29±0.31%, 0.22±0.10%, 0.20±0.12% of total fatty acids) and LA (15.36±4.02%, 14.45±2.90%, 13.87±2.45% of total fatty acids) at 18 months of age, compared with infants in the other intervention groups who received only iron–folic acid or placebo, respectively.

**Fatty acids intake during pregnancy and effects on infant growth and development**

There is a strong positive correlation of EFAs and AA + DHA serum concentrations of newborn babies and their mothers. The relative (per kilogram of body weight) status is higher in newborns than in mothers, suggesting a strong fetal and neonatal preference and need for these fatty acids. In preterm neonates, DHA status is positively related to parameters of fetal growth, such as birthweight, head circumference and birth length.

We found five studies from developing countries on the relationship between intake of fatty acids during pregnancy and growth and development outcomes of the offspring. Two of these studies were cross-sectional studies (Parra-Cabrera et al. 2008; Muthayya et al. 2009a) and three were randomized controlled trials (RCTs; Tofail et al. 2006; Mardones et al. 2008; Ramakrishnan et al., 2010) (Table 4). A significant positive correlation between EPA/DHA intake and birthweight was shown in a study in India. The study from India (Muthayya et al. 2009a) (Table 4), reported a significantly increased adjusted odds ratio of risk of low birthweight for women whose fish intake was in the lowest tertile in third trimester compared with those in the highest tertile but no difference in gestational duration. In the intervention study in low-income women in Chile (Mardones et al. 2008), increases in birthweight (65 g) and birth length (0.37 cm) were observed after ~30 weeks supplementation. However, compared with the control group, these women also received a higher dose of micronutrients together with omega-3 fatty acids, which may have contributed to the effect. On-treatment analysis in the study in Chile, found even higher birthweight (118 g), birth length (0.57 cm) and head circumference (0.20 cm) in women in the intervention group compared with women in the control group. In addition, women in the intervention group also had decreases in very preterm deliveries (2.1% vs. 0.4%, \( P = 0.02 \)) and marginal decreases in pre-eclampsia (3.4% vs. 1.6%, \( P = 0.083 \)) compared with control women. The national food distribution program for low-income pregnant women in Chile now includes milk fortified with ALA. In Mexico Ramakrishnan et al. (Ramakrishnan et al., 2010) assessed the impact of DHA supplementation (400 mg day\(^{-1}\)) during pregnancy on infant growth and development through a randomized controlled intervention trial. Overall, no effect was found on growth outcomes; however,
Table 4. Overview of studies on effect of omega-3 and omega-6 fatty acids in pregnant women on growth and development of infants

<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>N</th>
<th>Supplementation to mothers</th>
<th>Functional measurements: age at assessment</th>
<th>Outcomes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional studies (Muthayya et al. 2009a)</td>
<td>India</td>
<td>676</td>
<td></td>
<td></td>
<td>Birthweight</td>
<td>No significant association between DHA status of mother with birthweight. Women not consuming fish had a higher risk of LBW infant compared to women consuming &gt; median in third trimester</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fish consumption above the median was 9 g day⁻¹.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Parra-Cabrera et al. 2008)</td>
<td>Mexico</td>
<td>76</td>
<td>15 months ALA intake = 1.26 to 1.35 mg day⁻¹; DHA intake = 0.11 mg (intake from FFQ)</td>
<td>Brainstem auditory-evoked potentials (BAEP)</td>
<td>AA and not DHA intake significantly related to BAEP</td>
<td>FFQ based on consumption in last year and converted to g of food</td>
</tr>
<tr>
<td>Randomized controlled trials (Mardones et al. 2008)</td>
<td>Chile</td>
<td>552</td>
<td>Enrolment to delivery (appr. 8 months)</td>
<td>Birthweight, length, GA</td>
<td>65.4 g difference in birthweight, 95% confidence interval 15–126 g; P = 0.03 and the incidence of very preterm birth (34 weeks) was lower (0.4% vs. 2.1%; P = 0.03).</td>
<td>The intervention group also had higher quantity of MMN</td>
</tr>
<tr>
<td>(Tofail et al. 2006)</td>
<td>Bangladesh</td>
<td>249</td>
<td>Wk 25 to delivery</td>
<td>1: 1200 mg DHA + 1800 mg EPA C: 2250 mg LA + 270 mg ALA</td>
<td>BSID: 10 months</td>
<td>No effects on development. No effects on birthweight, birth length, or head circumference*</td>
</tr>
<tr>
<td>(Ramakrishnan et al. 2010)</td>
<td>Mexico</td>
<td>1040</td>
<td>Wk 18-22 to delivery</td>
<td>Birthweight, birth length, head circumference VEP, BAEP, visual attention, Bayley</td>
<td>No effects on growth, but positive effects on birthweight and head circumference in subgroup of supplemented primigravida</td>
<td></td>
</tr>
</tbody>
</table>

I, intervention group; C, control group; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; LA, linoleic acid; DPA, docosapentaenoic acid; VEP, visual evoked potential; HM, human milk; ERG, electroretinography; EEG, electroencephalogram; FT, Fagan Test of Infant Intelligence; IQ, intelligence quotient; K-ABC, Kaufman Assessment Battery for Children; BSID, Bayley Scales of Infant Development; MPS, means-end problem solving; MACDI, MacArthur Communicative Development Inventories; TAC, Teller Acuity Card procedure; GGM, Gesell Gross Motor; CLAMS, Clinical Linguistic and Auditory Milestone Scale; CAT, Clinical Adaptive Test; PDI, Psychomotor Development Index; ND, not determined; MMN, multiple micronutrients; GA, gestational age; FFQ, Food frequency questionnaire; ALA, alpha-linolenic acid; BAEP, brain stem auditory-evoked potentials. *Birth outcomes were not main outcomes of this follow-up study. These data were reported in baseline table of Tofail et al. 2006.
among a subgroup of primiparas, birthweight significantly increased by 99.4 g and length by 0.5 cm among supplemented women.

However, an intervention trial in Bangladesh did not show an impact of fish-oil supplementation on birthweight (Tofail et al. 2006) and similarly, in Mexico no impact of DHA supplementation on birthweight was observed in the general population (Ramakrishnan et al. 2010).

Impact of DHA or DHA + EPA intakes or supplementation of pregnant women on developmental outcomes of the offspring were reported by only one observational study from Mexico (Parra-Cabrera et al. 2008) and one randomized controlled intervention trial in Bangladesh (Tofail et al. 2006). Higher intakes of AA but not DHA were associated with improvements on brainstem auditory-evoked potentials in infants in Mexico (Parra-Cabrera et al. 2008), whereas no effects were found on infant development in Bangladesh following supplementation of their mothers during pregnancy (Tofail et al. 2006).

In summary, data from three out of five studies from developing countries suggest that a higher EPA/DHA intake or ALA supplementation during pregnancy may result in small improvements in birthweight and length, and gestational duration. Only two studies evaluated the impact on developmental outcomes with mixed results.

In contrast, a number of observational studies in developed countries show a significant positive association of fish consumption during pregnancy and birthweight (Olsen et al. 1993; van Eijsden et al. 2008) and visual and cognitive development of term infants and children (Daniels et al. 2004; Oken et al. 2005; Hibbeln et al. 2007). Also, RCTs from developed countries have shown that supplementation with DHA/EPA during pregnancy results in a modest increase in head circumference at birth (Sajewska et al. 2006) but not in birthweight and length. Moreover, a recent review of RCTs on omega-3 fatty acids supplementation in pregnant and lactating women, infants and children concluded that there is limited but suggestive evidence for a beneficial effect on visual development, and mental development and longer-term cognition in infants (Eilander et al. 2007).

To conclude, data from developing countries suggest that ALA or EPA + DHA intake/supplementation during pregnancy may improve birth length and weight and gestational age, but more rigorous RCTs would be needed to confirm this effect. The data from developing countries for developmental outcomes is currently too limited to draw a firm conclusion.

Fatty acid intake during lactation and effects on infant growth and development

Only three cross-sectional studies were found on breast milk levels of omega-3 fatty acids and functional outcomes in infants (Table 5). An observational study from Brazil in preterm infants found that breast milk total omega-3 fatty acids were positively associated with growth in children (Tinoco et al. 2009). Krasevec et al. found no relationship between breast milk DHA with visual acuity or growth in Cuban infants perhaps because DHA in breast milk was higher than found in many developed countries and the teller acuity cards may not have been sensitive enough to detect differences in visual acuity (Krasevec et al. 2002). Rocquelin et al. (2003) found that breast milk fatty acids were significantly associated with weight of infants in Congo but not in Burkina Faso (Rocquelin et al. 2003). The amounts of both ALA and DHA in breast milk in the Congo were twice that seen in Burkina Faso.

Studies in developed countries showed impacts of DHA supplementation in breastfeeding mothers on cognitive outcome (Jensen et al. 2005) and visual acuity of their infants (Innis 2007a). Three RCTs have assessed the effect of supplementing lactating mothers with DHA, on cognitive development of their children (Gibson et al. 1997; Jensen et al. 2005; Helland et al. 2008). These three studies found positive outcomes on cognition among children in the supplemented group compared with control. However, in one study, which included supplementation during pregnancy and lactation, these beneficial outcomes did not sustain in a longer-term follow-up at 7 years of age (Helland et al. 2008).

In conclusion, limited data from developing and developed countries suggest that DHA concentration
<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>N</th>
<th>Supplementation to mothers</th>
<th>Functional measurements: age at assessment</th>
<th>Outcomes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional studies (Krasevec et al. 2002)</td>
<td>Cuba</td>
<td>56</td>
<td>Amount of EFA in breast milk (ALA = 0.92% and DHA = 0.43%)</td>
<td>Visual acuity: 2 months</td>
<td>No associations between infant or maternal FA status and visual acuity</td>
<td>Breast milk LA/ALA was significantly associated with weight gain in Congo only</td>
</tr>
<tr>
<td>(Rocquelin et al. 2003)</td>
<td>Congo + Burkina Faso</td>
<td>102 + 101</td>
<td>Amount of EFA in breast milk Congo (ALA = 0.35% and DHA = 0.15%) Burkina Faso (ALA = 0.15% and DHA = 0.08%)</td>
<td>Weight: 5 months</td>
<td>LA/ALA ratio was 12:1 in Congo (340 mg ALA) and 53:1 in Burkina Faso (150 mg ALA)</td>
<td></td>
</tr>
<tr>
<td>(Tinoco et al. 2009)</td>
<td>Brazil (pre-term infants)</td>
<td>37</td>
<td>Until 6 months of gestational age</td>
<td>Breast milk</td>
<td>Height (cm), weight (g) and head circumference (cm)</td>
<td>Total n-3 PUFA was positively associated with weight gain (P = 0.05), height (P = 0.04) and body mass index of children (P = 0.05).</td>
</tr>
</tbody>
</table>

ALA, alpha-linolenic acid; DHA, docosahexaenoic acid; EFA, essential fatty acid; FAO, Food and Agriculture Organization; LA, linoleic acid; ALA, alpha-linolenic acid; PUFA, polyunsaturated fatty acids.
in breast milk or DHA supplementation during lactation might be linked to improved infant growth and psychomotor and cognitive development.

**Supplementation of infants (0–24 months of age) with fatty acids and effects on growth and development**

Five intervention studies were found in infants measuring growth and development outcomes (Table 6). Four studies (Unay et al. 2004; Adu-Afarwuah et al. 2007; El-khayat et al. 2007; Chen et al. 2010) showed positive effects of fatty acid interventions on growth and/or development, although in one of these studies (in China) (Chen et al. 2010), this effect could also have been attributed to the additional micronutrients provided. In contrast, another study in China (Ben et al. 2004) did not find a significant difference in growth or development. Adu-Afarwuah reported improvements in growth and motor development in Ghanaian infants (6–12 months) in the intervention group with a fat-based spread (Adu-Afarwuah et al. 2007). This fat-based spread provided LA (1.29 g/20 g) and ALA (0.29 g/20 g) whereas no effects on growth were observed in the other two intervention groups that only provided micronutrients. The authors speculated that other than energy, the different effects on growth could be explained by a significantly greater plasma ALA concentration in the fat-based spread group (Adu-Afarwuah et al. 2007) and perhaps the addition of milk in the spread. For development (motor milestone), all interventions showed improvement with greater improvements in the fat-based spread compared with control.

A study from Pakistan in protein energy malnourished infants (11.28±4.59 months) showed essential fat supplementation to positively impact both plasma AA and DHA levels as well as mental development index and psychomotor development index scores (Elkhayat et al. 2007). An RCT in Turkey found improvements in brainstem auditory evoked potentials in breastfed newborn healthy infants and those receiving infant formula with DHA compared with those receiving infant formula without DHA (Unay et al. 2004).

A study in China found improvements in motor development and growth among children 4–12 months of age in the study group receiving fortified whole fat soybean flour (high in ALA and fortified with five additional micronutrients) compared with unfortified rice flour (Chen et al. 2010).

Another study from China compared infants from four feeding groups: (1) AA + DHA supplemented formula; (2) standard formula; (3) breast milk; and (4) breast milk + supplemented formula. No significant differences were found for growth and development between the four feeding groups (Ben et al. 2004).

Overall, four out of five studies among infants and young children from developing countries showed improved growth and/or visual or motor development after supplementation with EFAs and DHA + AA. However, in two of these studies (Chen et al. 2010; Adu-Afarwuah et al. 2008), the beneficial effects may have been in part due to the additional micronutrients or protein that were provided together with the ALA.

Studies from developed countries have also reported positive effects of essential fat supplementation on visual acuity (Birch et al. 2002; Hoffman et al. 2003) and cognitive development in infants (Agostoni et al. 1995; Drover et al. 2009). A review from 2005 showed no effect of dietary ALA enrichment on term infant growth except at 12 months of age where infants consuming ALA-enriched formula were heavier and longer compared with control infants (Udell et al. 2005). On the other hand, no beneficial effects of DHA + AA supplementation of formula-milk on the physical (weight, length, head circumference), visual and neurodevelopmental outcomes of infants born at term were found in a number of meta-analyses of well-conducted RCTs from developed countries (Lapillonne & Carlson 2001; Makrides et al. 2005; Rosenfeld et al. 2009). Moreover, a recent Cochrane review on DHA + AA supplementation in term infants failed to demonstrate effects on vision, various aspects of cognitive development or physical growth (Simmer et al. 2008). It is suggested that high dose (100 mg DHA plus 200 mg AA) and prolonged duration (preferably 12 months) of supplementation to assess the effect of DHA + AA on cognitive development are more likely to yield positive results.

Overall, limited data from developing countries suggest that ALA or DHA supplementation is beneficial for infant’s growth and development in these...
### Table 6. Overview of studies on effect of omega-3 and omega-6 fatty acids and growth and development of children 0–2 years of age

<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>N</th>
<th>Subjects</th>
<th>Supplementation</th>
<th>Functional measurements: age of assessment</th>
<th>Outcomes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Ben et al. 2004)</td>
<td>China</td>
<td>245</td>
<td>Term infants</td>
<td>Birth until 6 months</td>
<td>F1: 0.18% AA + 0.18% DHA</td>
<td>BSID: 3, 6 months</td>
<td>No significant differences for growth and development between the four feeding groups</td>
</tr>
<tr>
<td>(El-khayat et al. 2007)</td>
<td>Pakistan</td>
<td>42 + 15 PEM infants</td>
<td>Control healthy children</td>
<td>8 weeks</td>
<td>PUFA supplemented vs. control group on nutritional rehabilitation according to WHO guidelines</td>
<td>Mental development index (MDI), PDI scores of BSID-II</td>
<td>Positive correlations between plasma AA and DHA levels and both MDI and PDI scores</td>
</tr>
<tr>
<td>(Adu-Afarwuah et al. 2007)</td>
<td>Ghana</td>
<td>298</td>
<td>Infants</td>
<td>6 months</td>
<td>Nutributter® with 108 kcal and 19 vitamins and mineral and LA 1.29 (g) ( \text{ALA} = 0.29 \text{g} ) vs. Sprinkles® (6 vit &amp; min) and nutri tab (16 vit &amp; min)</td>
<td>Anthropometric measurements</td>
<td>NB group had a significantly greater weight-for-age z-score (WAZ) ((-0.49 \text{ vs. } -0.65)) and length-for-age z-score (LAZ) ((-0.20 \text{ vs. } -0.38)) than the NT group and the NT and SP groups combined</td>
</tr>
<tr>
<td>(Unay et al. 2004)</td>
<td>Turkey</td>
<td>80</td>
<td>Healthy infants</td>
<td>Birth to 16 weeks</td>
<td>F1: 0.5% DHA</td>
<td>BAEP: 1, 16 weeks</td>
<td>Positive: more rapidly maturation of auditory brainstem at 16 weeks in F1 than F2</td>
</tr>
<tr>
<td>(Chen et al., 2010; Wang et al., 2007)</td>
<td>China</td>
<td>1478</td>
<td>Children 4–24 months</td>
<td>RCT C = unfortified rice flour, I = fortified soy flour</td>
<td>DQ, Motor dev. ( \text{WAZ} )</td>
<td>I group had less of a decrease in than the control group in LAZ (effect size of ~0.37). Cognitive and motor development at 24 months significantly higher in I group</td>
<td></td>
</tr>
</tbody>
</table>

F: formula; AA, arachidonic acid; ALA, alpha-linolenic acid DHA; BSID, Bayley scales of infant development; PEM, Protein energy malnutrition; WHO, World Health Organisation; PUFA, Polysaturated fatty acids; LCPUFA, long chain polysaturated fatty acids; MDI, Mental Development Index; PDI, Psychomotor Development Index; LA, linoleic acid; NB, Nutributter®; NT, Nutritab; SP, Sprinkles®; BAEP, brainstem auditory-evoked potentials; RCT, randomised control trial; I, intervention group; C, control group; DHA, docosahexaenoic acid; DQ, Development quotient; WAZ, weight-for-age z scores; LAZ, length-for-age z scores.
Supplementation of children >2 years of age with fatty acids and effects on growth and development

Only three studies in older children (6–10 years) have been conducted in developing countries and are listed in Table 7. The 3 studies showed no effects on growth following fish flour spread rich in EPA + DHA in South African children (Dalton et al. 2009) and EPA/DHA supplementation in school-age children from Indonesia and India (Osendarp et al. 2007; Muthayya et al. 2009b). These three studies also measured cognitive development outcomes. Only one study (Dalton et al. 2005) showed improvement of verbal learning ability and memory of children when supplemented with a fish-flour spread rich in EPA + DHA whereas the other two studies (Osendarp et al. 2007; Muthayya et al. 2009b) showed no effect on cognition after EPA/DHA supplementation.

Five RCTs in healthy children from developed countries have assessed the effect of EPA and DHA on cognitive function and one of them has also measured effects on growth. One study was conducted in preschool children aged 4 years (Ryan & Nelson 2008) and the others in children aged 6–10 years (Osendarp et al. 2007; Kennedy et al. 2009; Kirby et al. 2010; McNamara et al. 2010). Based on results of these five trials, there is little evidence for a beneficial effect of EPA + DHA on growth and cognitive function in older children.

In conclusion, three studies in developing countries suggest that there is no evidence for improvements in growth following omega-3 fatty acid supplementation in children >2 years of age. This is consistent with the findings of studies conducted in developed countries. For cognitive development, supplementation with lower dosages of ~100 mg EPA/DHA seemed not effective in older children from developing countries.

Discussion

Data summarized in this review suggest that omega-3 fatty acids, and DHA in particular, during pregnancy, lactation and early life, may have significant benefits for infant growth and development in developing countries. However, limited available dietary intake data suggest low intakes of omega-3 fatty acids compared with the AI are common among young children, especially those who are no longer breastfed, and among pregnant and breastfeeding women. In part this is due to lower total intakes of fat and additionally, due to low intakes of foods high in omega-3 fatty acids, including animal products and certain oils (soy, canola).

Limited data from pregnancy trials in developing countries suggest that supplementation or increased intakes of DHA + EPA or DHA only during pregnancy may result in small benefits in birth outcomes such as weight and length, and gestational age. These findings are not in agreement with overall evidence from RCT in developed countries, although, some observational studies from developed countries also observed positive associations between omega-3 intakes and birth outcomes similar to developing countries.

Positive birth outcomes after omega-3 fatty acid interventions, although observed in only a limited number of studies, may be related to the role of omega-3 fatty acids in cell growth and multiplication (Innis 2005), thus exerting a positive effect on weight and length of the fetus and infant. Evidence is further emerging that prenatal EFAs may be involved in programming of later health and development (van Eijsden et al. 2008). Currently, evidence from a limited number of studies suggest an association between maternal omega-6 and omega-3 fatty acid status and birthweight, length and body composition (Micallef et al. 2009) of the child during early infancy. It has been hypothesized that high omega-6 to omega-3 status raises tissue AA, which increases prostacyclin production and, in turn, stimulates signaling pathways implicated in adipogenesis. However, more research is needed to determine how these fatty acids influence body size and body composition of fetuses and infants.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Location</th>
<th>N</th>
<th>Age</th>
<th>Duration</th>
<th>Intervention</th>
<th>Measurements</th>
<th>Outcomes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nemo study group (Osendarp et al. 2007)</td>
<td>Indonesia</td>
<td>384</td>
<td>6- to 10-year-old children</td>
<td>6 day week¹ for 12 months</td>
<td>I: 88 mg DHA + 22 mg EPA C: none</td>
<td>Height, weight, WISC-III, NEPSY, WAIS, RAVLT, WIAT baseline, 6 months, 12 months</td>
<td>No effects on growth and cognition</td>
<td></td>
</tr>
<tr>
<td>(Muthaya et al. 2009b)</td>
<td>India</td>
<td>598</td>
<td>6- to 10-year-old children</td>
<td>6 day week¹ for 12 months</td>
<td>I: 900 mg ALA +100 mg DHA C: 140 mg ALA</td>
<td>Height, weight, MUAC K-ABC, WISC-III, RAVLT, NEPSY, Number Cancellation Tests baseline, 6 months, 12 months</td>
<td>No effects on growth and cognition                                      No control group receiving no omega-3 FA was included</td>
<td></td>
</tr>
<tr>
<td>(Dalton et al. 2005)</td>
<td>South Africa</td>
<td>183</td>
<td>7- to 9-year-old children</td>
<td>7 day week¹ for 6 months</td>
<td>I: Fish flour containing 335 mg ALA +82 mg EPA + 192 mg DHA + 1507 mg LA +23 mg AA C: Bread flour containing 84 mg ALA +15 mg EPA + 36 mg DHA + 2511 mg LA +7 mg AA</td>
<td>Height, weight, HVLT, reading, spelling tests baseline, 6 months</td>
<td>No effects on growth, positive effect of fish flour on HVLT</td>
<td>Fish flour may also have contained other nutrients (e.g. iodine) that may have contributed to the effect</td>
</tr>
</tbody>
</table>

I, intervention group; C, control group; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; HVLT, Hopkins Verbal Learning Test; MUAC, mid-upper arm circumference; WISC, Wechsler Intelligence Scales for children; NEPSY, Neuropsychological Assessment tool; WAIS, Wechsler Adult Intelligence Scale; RAVLT, Rey Auditory Verbal Learning Test; ALA, alpha-linoleic acid; FA, Fatty acid; K-ABC, Kaufman Assessment Battery for children.
Omega-3 fatty acids, in particular, DHA, are also known to play an essential role in the development of the brain and retina. Observational studies from developed countries suggested positive associations or effects of DHA status or omega-3 fatty acid supplementation during pregnancy on improved infant development outcomes. However, only two studies from developing countries assessed effects of omega-3 fatty acids on infant development and results were mixed. RCTs are needed to confirm these benefits in developing countries using validated methods to assess development in these settings.

Based on the limited number of studies from developing countries, our review suggests the results about the relationship between enhanced DHA concentration of breast milk during lactation and infant growth, psychomotor and cognitive development were mixed. Unfortunately, information from intervention trials with DHA supplementation during lactation is lacking from developing countries, and therefore the causality of this association cannot yet be confirmed. Given the importance of breast milk in the EFA and DHA intakes of the infant during the period of exclusive breastfeeding and beyond, such studies are urgently needed.

The large variability in breast milk fatty acid content may complicate the interpretation of findings from these studies. Reviews have shown that the omega-3 content and especially DHA content of breast milk varied significantly among lactating women from developing countries. In some countries such as Pakistan, India and rural South Africa, lactating women had very low DHA intake or breast milk content whereas women in the Philippines, Congo and Cuba had high DHA content of breast milk. There are several factors responsible for this large range of breast milk DHA: firstly, higher intakes from fatty fish are associated with higher maternal DHA status (Otto et al. 2000; Food and Nutrition Board 2007). Secondly, the variability in breast milk DHA may be related to variations in the amount of DHA synthesized in the body, and variability in status of nutrients required for DHA synthesis. Thirdly, the conversion also depends on the polymorphism in the fatty acid desatur (FADS) gene cluster, and therefore some individuals have a higher biosynthesis rate than others (Lattka et al. 2010a,b). Lastly, for indicators of EFA status, there are many significant measurement issues as there are no established ‘gold standard’ methods for assessment, and each study uses different assessment methods potentially leading to large variation.

A review of studies in infants and children up to 24 months of age, omega-6 and/or omega-3 fatty acid supplementation was found to improve growth and/or visual or motor development in developing countries, which is in contrast to findings from meta-analysis (including well-conducted RCTS) not showing beneficial effects of supplementation in infants from developed countries (Simmer et al. 2008). These differential effects of supplementation, despite a seemingly similar EFA status, could be due to: (1) overall lower total fat and micronutrient intakes in the diet and complementary foods in the populations studied; (2) an overall disadvantaged nutritional status in the populations studied (Smit et al. 2004; El-khayat et al. 2007; Tinoco et al. 2009); and (3) higher infection load leading to higher EFA needs and requirements in infants from developing countries. Furthermore, micronutrient deficiencies may contribute to impaired EFA bioavailability and metabolism (Smit et al. 2004), and supplementation with multiple micronutrients (iron, folic acid, zinc and vitamins) was associated with an increase of LA and a-linolenic acid levels in infants (Agostoni et al. 2007).

Fatty acid supplementation showed improvement in cognition or development in infants from developing countries. These benefits were more pronounced in undernourished children and apparently healthy children from low socioeconomic status. Malnourished infants and children are known to have lower development scores compared with healthy subjects (Grantham-McGregor 1995) and nutritional interventions, such as supplementation with omega-3 fatty acids, may therefore more likely result in improved development scores in poorly nourished populations as has been shown in studies from Pakistan (El-khayat et al. 2007). The importance of providing an appropriate supply of omega-3 and omega-6 fatty acids, especially DHA and AA, is likely to be relevant in early childhood in these settings because both fatty acids continue to accumulate most rapidly in brain
gray matter during the first 2 years of life (Martinez 1992).

In older children above 2 years of age, no benefits of omega-3 fatty acids were observed on growth or cognition in studies from developing countries, which is line with findings from developed countries (Osendarp et al. 2007; Kennedy et al. 2009; Kirby et al. 2010; McNamara et al. 2010).

Fatty acid intake and status, and in particular omega-3 and DHA status, in infants and children from developing countries varied from lower or similar or even higher when children relied on breast milk compared with the fatty acid status of infants from developed countries (Agostoni et al. 2007). However, when children increasingly eat other foods, and correspondingly breast milk intake is reduced, diets of young children in developing countries consequently become too low in fat and omega-3 fatty acids.

Recommendations

Overall, the findings from this review suggest a critical window of opportunity for adequate EFA intake, and in particular ALA and DHA, intakes during pregnancy, lactation and the period of complementary feeding, stressing the importance of these fatty acids for vulnerable populations in developing countries.

Ensuring AIs of fat and especially omega-3 fatty acids, through foods high in these nutrients is needed among mothers and children in developing countries to meet current recommendations. Foods made from soy oil, full-fat soy flour and animal products are good sources of ALA. Promotion of exclusive breastfeeding and continued breastfeeding after 6 months of age and increased intake of fatty fish or algae or supplementation/fortification will increase DHA and EPA intake. This may be more desirable than increasing ALA intake, especially when energy intakes are low, because additional ALA intake would be preferentially used for energy expenditure rather than conversion to EPA and DHA. However, currently costs of DHA-enriched foods or supplements are much higher than foods naturally high in ALA, which could limit the impact of such interventions.

Exclusive breastfeeding until 6 months of age, and continued breastfeeding should continue thereafter until 2 years and beyond. Improving access to foods high in omega-3 fatty acids to improve complementary feeding is needed to ensure adequate EFA and omega-3 intakes in these populations.

Acknowledgements

We would like to thank Zhenyu Yang and Elizabeth Zehner for their help with the collection and review of papers used in this paper, and Mary Arimond for extensive comments on earlier drafts.

Funding

Funding for this paper came from the Global Alliance for Improved Nutrition (GAIN).

Conflicts of interest

RKH, AE, SJMO are employees of Unilever. Unilever markets food products made of vegetable oils, including margarines and dressings.

References


Barbara J.T. & Lapillonne A. (2009) Background paper on...


Essential fatty acids for growth and development


Balancing nurturance, cost and time: complementary feeding in Accra, Ghana

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Abstract

This paper presents a picture of the general patterns of complementary feeding behaviours in urban Ghana. A focused ethnographic study protocol for assessing complementary feeding developed for the Global Alliance for Improved Nutrition was used to collect data from caregivers of children 6–24 months of age. We examined the multiple factors that influence the selection of foods for infants and young children in this urban setting, and found that economic factors, health beliefs and other nurturing-related values, access to food and issues of convenience all play important roles. We conclude that the interactions of nurturance, cost and time are vectors that affect feeding decisions.

Keywords: social determinants of infant feeding, focused ethnographic studies, infant feeding beliefs and practices, use of commercial infant cereals, women’s time allocation, breastfeeding.

Introduction

In the nutrition and public health community, there is now widespread understanding that complementary feeding is not only about ‘what’ is fed, but also about ‘how’, ‘when’, ‘where’ and ‘why’ (Pelto et al. 2003). In other words, that in addition to macro- and micronutrients, complementary feeding involves behaviour and the determinants of behaviour. Consequently, understanding complementary feeding behaviours and their determinants is critical for the design and development of interventions to prevent undernutrition and future obesity during the period from 6 to 24 months of age, and research to facilitate this understanding is essential.

Several different approaches are currently employed to conduct social research on complementary feeding. The various approaches, which use quantitative or qualitative research methodologies, or a combination of both, have their origins in different social science and public health disciplines. Although they often share common goals about the insights and information they hope to obtain, they draw on different methodologies and rest on different theoretical frameworks, and thus can be seen as providing ‘complementary’ contributions to understanding and evaluating infant and young child feeding.

One approach to the study of complementary feeding is focused ethnography. The concept of ‘focused ethnographic studies’ (FES) is derived from anthropology (Pelto & Gove 1992; Manderson 1998). In practice, the research protocols typically use a mixed-method approach to examine specific questions, which have been identified before a study is
undertaken. Thus, they are not only focused on a particular topical area of human behaviour and its determinants, but also on a specific set of questions; the answers to which are important for actions. Because the methodology rests on exploratory, qualitative techniques, FES provides insights that go beyond the immediate, pre-specified questions to reveal larger aspects of the topic of study, including the socio-cultural context.

In this paper, we present the results from a study based on a FES approach. The study was conducted in Accra, Ghana in 2010 (Pelto & Armar-Klemesu 2010a).

The specific question for the research in Accra, which was undertaken on behalf of the Global Alliance for Improved Nutrition (GAIN), was whether a fortified, non-instant cereal had the potential to be widely adopted in these (or similar Ghanaian) urban settings. In the course of examining this question, we also learned about what caregivers of infants and young children (IYC) are doing with respect to complementary feeding (what, how, when and where) and the reasons for their choices and decisions. In this paper, we are concerned with this wider picture and its implications, rather than the answers to GAIN’s specific questions about the potential future for a fortified, non-instant cereal.

Materials and methods

The study design

The operational strategy of our FES was to collect information about essential aspects of IYC feeding behaviour as efficiently as possible by stratifying data collection according to sources of information. In Accra, the first level of segmentation was by child age. In recent years, the acronym IYC has come to refer to children 6–24 months of age. However, as the biological and behavioural variability across the 18 months of IYC status is large, it is essential to break it down into smaller age categories. We subdivided the age range (6–24 months) into four divisions: 6–8 months; 9–12 months; 13–18 months; and 19–24 months. Respondents could then be recruited in relation to these four categories to ensure that all age groups were represented. The second segmentation was by economic status. In order to examine behaviour in families who had sufficient income to purchase complementary foods, we did not interview respondents from the very poorest households, but we sought to include a range of economic conditions, with an emphasis on households with lower socioeconomic status (SES). We measured SES with an established method based on living standards measures (LSMs) derived from the Ghana Living Standards Survey indicators. The LSM method of SES categorization has wide application in market and social research, and has previously been used to assess market opportunities for processed cassava products in Ghana (Collinson et al. 2001, 2003).

To obtain information on caregiver perspectives, we conducted individual interviews, which typically involved two visits to a household. The interview protocol draws on several qualitative data collection methods, including cognitive mapping techniques, as well as standard demographic and nutrition methods. The protocol is organized into modules, each of which is designed to obtain information on a specific topic. The modules, which varied in length depending on the topic, are the equivalent of sections within a questionnaire.

Key messages

- Application of ethnographic techniques is an effective and efficient method for obtaining and interpreting data on complementary feeding.
- Mothers in Accra have strongly held views about the importance of foods for child health and growth.
- Beliefs and values about nutrition and child health compete with the constraints imposed by low economic resources and time demands.
- Finding a balance between food costs, demands on time and beliefs and values about how to promote their children’s health pose a continuous challenge for mothers in urban Ghana.
All of the respondents, mothers of IYC, were interviewed with a core set of modules, which included socio-economic and demographic data and child feeding practices, as well as modules designed to obtain information on beliefs, attitudes and knowledge. Some modules were used only in subsets of respondents because we needed only a few informants to obtain an adequate picture. For example, a module designed to obtain information on types of foods that are fed to infants was applied only with the first respondents as the results quickly became redundant. With some respondents, we applied modules in addition to the core set in order to obtain insights about the wider context in which infant feeding beliefs and behaviours are imbedded.


The study area and the sample

The study was conducted in the Greater Accra Metropolitan Area in eight different residential areas representing a wide range of conditions from dense urban neighbourhoods to peri-urban areas. Some of the areas have a long settlement history, while others are recently established. Some are populated with households who have been in Accra for many years. Others are comprised mainly of migrants from other parts of the country. Some are home to families that are relatively well off; others are composed mainly of families who are very poor. Together, they capture a wide cross section of Accra society.

Interviews were conducted in Twi or Ga, two main local languages, and, with permission, were audio recorded. Although respondents spoke in the local language, they also used English words from time to time over the course of the interview. This is a common occurrence in urban Ghana when local languages are being spoken. Two of the respondents were better able to express themselves in English, so their interviews were conducted in a mix of Ga or Twi and English.

To recruit respondents for our study, we laid out a grid with the combination of age and LSMs categories. Field staff visited each of the eight communities and randomly selected a street on which to start approaching potential respondents. The first screening was for child age, after which, the LSM screening questions were asked. As recruiting progressed, and child age/LSM categories were filled, the number of women who were screened increased because of the need to meet the remaining respondent slots. Using this method, a total of 30 caregivers (mothers) were recruited for the study. Table 1 shows the socio-demographic and LSM characteristics of the sample.

Data analysis

The tapes from the interviews were transcribed and translated. These records, together with the interview-

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of index child (months)</td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>7</td>
</tr>
<tr>
<td>9-12</td>
<td>11</td>
</tr>
<tr>
<td>13-18</td>
<td>7</td>
</tr>
<tr>
<td>19-24</td>
<td>5</td>
</tr>
<tr>
<td>Age of respondents (years)</td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>1</td>
</tr>
<tr>
<td>20-29</td>
<td>10</td>
</tr>
<tr>
<td>30-39</td>
<td>19</td>
</tr>
<tr>
<td>Total household size</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3-4</td>
<td>9</td>
</tr>
<tr>
<td>5-6</td>
<td>13</td>
</tr>
<tr>
<td>7-8</td>
<td>3</td>
</tr>
<tr>
<td>&gt;8</td>
<td>3</td>
</tr>
<tr>
<td>Number of children of respondent</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2-3</td>
<td>12</td>
</tr>
<tr>
<td>4-5</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Number of children under six in household</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Living Standard Measures (LSM) status</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td>14</td>
</tr>
<tr>
<td>5-7</td>
<td>7</td>
</tr>
<tr>
<td>8-10</td>
<td>9</td>
</tr>
</tbody>
</table>
ers’ notes taken during the discussions with respondents, provided the corpus of data for text analysis. Text analysis was conducted independently by both authors of the paper. When differences in interpretation occurred, these were discussed and reconciled. The small size of the database made it feasible to carry out the text analysis without using computer tools to facilitate coding. We worked directly with transcripts, creating files of statements on specific topics and issues. With small samples (30 or less depending on the module) and hand tabulation, simple descriptive analysis was possible without the assistance of a qualitative data analysis software program. Quantitative data from the modules were entered and analyzed in Excel.

Results and discussion

Characteristics of the sample

From Table 1, we see that the respondents represent a wide range in age, experience in child care (from new mothers to women with several children) and in household composition. The majority of the respondents have more than one child under the age of 6. There is also a wide range in SES. All of the households had electricity, but the majority of women are living in difficult conditions. Many of the women in our respondent sample keep the house without the advantages of running water, an indoor toilet, a refrigerator or a gas or kerosene cooking stove.

As shown in Table 2, many respondents estimated that they spend just under 10 cedis ($7.00) a day on food for the household, while the estimates of the highest LSM respondents were about 13 cedis ($9.00) per day. Women did not have difficulty estimating the amount of money they spent on food for their infant or young child, and we see that there is very little variation across LSM groups, with an estimate of 1.6 cedis ($1.12) in the lowest LSM categories and 2.1 cedis ($1.50) in the highest groups. On average, 25% of household food expenditure is for foods for IYC.

Feeding practices

To generate a qualitative picture of feeding practices, we administered a classic 24-h recall, beginning with asking about the first item the child had eaten on waking and continuing through the day, for the day prior to the interview. Table 3 shows the results for the 30 children whose mothers we interviewed. A description of the cereal-based foods in this table can be found in Table 4.

The phrase ‘complementary feeding’, which is used with reference to feeding practices during the period from 6 to 24 months, is intended to remind us that foods given to IYC are intended to be ‘complementary’ to breast milk. All of the children in our sample were breastfed at birth. Twenty-two (73%) of the 30 children were still breastfed at the time of the interview. All seven children in the 6–8 months age group were breastfed, while nine (82%) and six (50%) of those in the 9–12 and 13–24 months groups, respectively, were breastfed. Mothers were generally not able to estimate the number of times they breastfed their child in a day, and most expressed the idea that they breastfed an uncountable number of times, even with the older children.

The number of times complementary foods were given to the child (feedings) was derived from the 24-h food record. We find that two of the seven infants in the 6–8 months age group were fed less than the recommended ‘twice a day’. Eight of the 11 infants in the 9–12 months age group and all of the 12 in the 13–24 months age group were fed the recommended minimum of three times a day.

Cereal-based foods in the form of instant cereals and porridge, and as traditional family staples consumed with soup and stews, predominate. What is particularly striking in these food records is that 11 of the 30 IYC received Cerelac (Nestlé Ghana Ltd,

Table 2. Daily food expenditures

<table>
<thead>
<tr>
<th>LSM (high to low)</th>
<th>Household food expenditures mean and (SD)</th>
<th>Expenditures for IYC mean and (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10</td>
<td>12.9 (7.0)</td>
<td>2.1 (1.2)</td>
</tr>
<tr>
<td>5-7</td>
<td>9.3 (5.8)</td>
<td>2.4 (1.3)</td>
</tr>
<tr>
<td>3-4</td>
<td>9.2 (2.9)</td>
<td>1.6 (0.6)</td>
</tr>
</tbody>
</table>

LSM, living standards measures; SD, standard deviation; IYC, infants and young children.
Accra, Ghana), a commercial, fortified, instant porridge that is sold, ready to mix with water or milk, in every community in our study. The number of times in a day that these 11 children ate Cerelac varies from once to three times a day. Traditional porridge, koko and Hausa koko, are also very common in the food records. What is surprisingly low is the number of times that weanimix or tom brown (generic or branded, commercial, non-instant, usually multigrain cereal) appears in the recalls.

Infants are more likely to be given porridge or instant cereal as the first meal of the day, whereas young children (a year and above) are typically consuming tea, or a chocolate drink (Milo Nestlé Ghana Ltd, Accra, Ghana), with or without bread, as the first food in the morning. These are family breakfast foods, and, as can be seen in the table, the foods that follow later in the day are also family foods, which suggest that many children are no longer being given specially prepared complementary foods in the second year of life.

There is a notable absence of fresh fruit in the records. While this may reflect actual dietary intake, it is probable that respondents failed to report them, even with the typical prompting that characterizes data collection with a 24-h recall, because they do not regard fruit as food (see below). In fact, in another part of the interview, many of the women said that they felt that children should be given fruit, particularly fruit juices, because they are health promoting.

### Table 3. IYC food intake records for the day prior to the interview (youngest to oldest)

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>BF</th>
<th>Feed 1</th>
<th>Feed 2</th>
<th>Feed 3</th>
<th>Feed 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Yes</td>
<td>Hausa koko</td>
<td>Hausa koko</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Yes</td>
<td>Koko</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Yes</td>
<td>Banku + stew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Koko</td>
<td>Rice and egg stew</td>
<td>Banku + egg stew</td>
<td>Cereal®</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Mashed kenkey</td>
<td>Mpotompoto</td>
<td></td>
<td>Cereal®</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Koko + soya</td>
<td>Banku + soya + okro stew</td>
<td>Koko + soya</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>No</td>
<td>Hausa koko</td>
<td>Mpotompoto</td>
<td>Mashed yam + garden egg stew</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>Koko</td>
<td>Cereal®</td>
<td></td>
<td>Cereal®</td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>Koko</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>Cereal®</td>
<td>Cereal®</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>No</td>
<td>Tom brown</td>
<td>Rice + stew</td>
<td>Mashed kenkey + milk</td>
<td>Hausa koko + milk</td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>Mashed kenkey</td>
<td>Mpotompoto</td>
<td>Cereal®</td>
<td>Banku + stew</td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>Weanimix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>Koko</td>
<td>Tuo zaafi + ayoyo soup</td>
<td>Koko</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Yes</td>
<td>Cereal®</td>
<td>Rice + stew</td>
<td>Banku + okro soup</td>
<td>Cereal®</td>
</tr>
<tr>
<td>12</td>
<td>Yes</td>
<td>Tea + bread</td>
<td>Instant wheat cereal</td>
<td>Cereal®</td>
<td>Fried spiced plantain</td>
</tr>
<tr>
<td>13</td>
<td>Yes</td>
<td>Cereal®</td>
<td>Rice and stew</td>
<td>Banku + okro soup</td>
<td>Cereal®</td>
</tr>
<tr>
<td>15</td>
<td>Yes</td>
<td>Hausa koko</td>
<td>Cereal®</td>
<td>Mashed kenkey</td>
<td>Mpotompoto</td>
</tr>
<tr>
<td>15</td>
<td>Yes</td>
<td>Milo + bread</td>
<td>Jollof rice</td>
<td>Indomie instant noodles</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Yes</td>
<td>Milo + bread</td>
<td>TZ + ayoyo</td>
<td>Mashed Kenkey</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Yes</td>
<td>Tea + bread + fried egg</td>
<td>Tea + bread + egg</td>
<td>Tea + bread + egg</td>
<td>Banku + palm soup</td>
</tr>
<tr>
<td>18</td>
<td>Yes</td>
<td>Rice porridge + bread</td>
<td>Rice and stew</td>
<td>Fufu + palm nut soup</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>No</td>
<td>Milo</td>
<td>Cereal®</td>
<td>Rice + stew</td>
<td>Cereal®</td>
</tr>
<tr>
<td>18</td>
<td>Yes</td>
<td>Milo + fried egg + sausage</td>
<td>Cereal®</td>
<td>Banku + okro soup</td>
<td>Jollof rice + vegetables</td>
</tr>
<tr>
<td>20</td>
<td>No</td>
<td>Weanimix + nido</td>
<td>Rice + palava sauce</td>
<td>Nutrolac</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>No</td>
<td>Tea</td>
<td>Rice + stew</td>
<td>Banku + okro soup</td>
<td>Kenkey + groundnut soup</td>
</tr>
<tr>
<td>21</td>
<td>No</td>
<td>Milo + bread</td>
<td>Banku + stew</td>
<td>Akple (banku) + okro</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>No</td>
<td>Cold Milo</td>
<td>Banku + okro soup</td>
<td>Rice + stew + sausage</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>No</td>
<td>Bread</td>
<td>Hausa koko</td>
<td>Rice + stew</td>
<td>Jollof rice</td>
</tr>
</tbody>
</table>

IYC, infants and young children.
We used an ethnographic technique known as ‘free listing’ to elicit an emic inventory of the foods that are considered appropriate for infants and children. The technical term emic is used in anthropology to refer to ‘the insider’s perspective’, as contrasted with the perspective of the investigator. Sixteen specific foods were spontaneously described by respondents. The results of the free listing were not a definitive list of all the foods that children in urban Ghana receive, and many of the foods that appear on the 24-h recall were not mentioned. We interpret this result as evidence that the request for a spontaneous list of complementary foods elicits the foods that are most salient from the mothers’ perspectives. Of the 16 foods that women mentioned, five were porridge. However, we also observed a pattern in which specific foods are linked to child age: Porridge received first mentions for 6- to 8-month-old infants, while free listing of foods for children in the 19–24 months typically elicited items that were collectively referred to as ‘family foods’, and porridge was mentioned only after probing or prompting. Table 4 shows all the IYC foods that are given as porridge. Those that were mentioned spontaneously in the free listing are indicated in boldface type.

### Table 4. IYC Foods given as porridge

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Koko</strong></td>
<td>Traditional fermented maize porridge; also referred to as white koko; usually made at home</td>
</tr>
<tr>
<td><strong>Hausa koko</strong></td>
<td>Fermented millet porridge, usually purchased ready-to-eat from local (street) food vendors</td>
</tr>
<tr>
<td><strong>A commercial instant cereal (Cerelac®)</strong></td>
<td>Fortified instant cereal manufactured by a multi-national company; available in a variety of grains and flavors and in multiple package sizes, including single-serving packets; mixed with water or milk. It is made from.</td>
</tr>
<tr>
<td><strong>Home-processed tom brown</strong></td>
<td>‘Tom brown’ is a generic name for a variety of cereals prepared as porridge. Home processed is usually made from roasted maize flour.</td>
</tr>
<tr>
<td><strong>Enriched tom brown/weanimix/prepared at home or purchased from health centres</strong></td>
<td>Weanimix is used interchangeably with tom brown for cereals prepared from maize, soya beans and groundnuts roasted and milled together into composite flour; prepared as porridge.</td>
</tr>
<tr>
<td><strong>Commercial, unfortified (branded) tom brown</strong></td>
<td>Processed multi-grain cereals/legume composite flours; prepared as porridge.</td>
</tr>
</tbody>
</table>

We used an ethnographic technique known as ‘free listing’ to elicit an emic inventory of the foods that are considered appropriate for infants and children. The technical term emic is used in anthropology to refer to ‘the insider’s perspective’, as contrasted with the perspective of the investigator. Sixteen specific foods were spontaneously described by respondents. The results of the free listing were not a definitive list of all the foods that children in urban Ghana receive, and many of the foods that appear on the 24-h recall were not mentioned. We interpret this result as evidence that the request for a spontaneous list of complementary foods elicits the foods that are most salient from the mothers’ perspectives. Of the 16 foods that women mentioned, five were porridge. However, we also observed a pattern in which specific foods are linked to child age: Porridge received first mentions for 6- to 8-month-old infants, while free listing of foods for children in the 19–24 months typically elicited items that were collectively referred to as ‘family foods’, and porridge was mentioned only after probing or prompting. Table 4 shows all the IYC foods that are given as porridge. Those that were mentioned spontaneously in the free listing are indicated in boldface type.

**An overview of mothers’ concerns about health and nutrition**

We begin our presentation of the results and discussion about beliefs, knowledge and values with an overview of mothers’ concerns about health and nutrition. To set these concerns within the larger context of child caregiving, we first asked our respondents to describe the kinds of problems and challenges that families with IYC face. Mansah, a young mother with one child 20 months of age, elaborated her views as follows:

You do not necessarily need money to take good care of your child. But you can manage to keep the child healthy so that everybody will commend you for taking good care of her . . . I do not take delight in seeing my child play on the bare floor like other children. This is because some germs may be picked up by the child. I also keep an eye on wherever she goes to prevent accidents. I also make sure that whoever is going to pick her up is well kept. I also ensure her diapers are regularly changed to prevent rashes. I also make sure she is bathed and wearing neat clothing. As for food, she eats well so I make sure she has food all the time . . . Feeding, medication, hygiene are all part of the good care. I think they make the child grow well in a healthy environment. Some children are small for their ages because they did not get the kind of care that they should have. But a well cared for child grows well and is a delight to the mothers and others around her. With good care, a two year old child can look like a 4 or 5 year old child.

Some mothers responded to our opening question with a diverse set of health concerns and did not bring up food-related issues until we asked a probing
question. For example, Jenny, the mother of a 7-month-old, said:

Well, my concerns have to do with the health of the child. Sometimes they fall sick and you need to give them medications to make them well. Supposing you give the medications, and the baby is still not well, you send her to the hospital... As a mother you need to constantly check the baby’s diapers to be sure the baby is not wet, or else the baby gets a lot of discomfort and may even develop heat rashes. So the personal hygiene of the child is also very important...You have to be vigilant to ensure that the child does not put dangerous things into her mouth. We must also ensure the child is bathed well and wears clean clothes.

Interviewer: What about food? Is food another thing that concerns you?
Jenny: Food is very important. When I wake up every morning, I have to see to it that the child has food to eat.

Another respondent, Maureen, also gave us a list of several different issues. When we said, ‘You mentioned education, healthy eating, preventing him from getting hurt and money. Among these, which do you think is the most important in ensuring your child’s health?’ her reply was, ‘Healthy eating’.

A few respondents immediately began talking about food and nutrition. Sarah, the mother of a 6-month-old and four other children, said,

I am mainly concerned about her feeding. I make sure she eats nutritious foods. If her appetite goes down, I take her to a pharmacist to prescribe some drugs for me. I also prevent them from playing under the scorching sun... if my child feeds well, she will always be healthy.

One respondent said, ‘The major problem is feeding because each and every morning when one wakes up, she has to think about the kind of food to give to the child’. Another respondent, Mina, whose 17-month-old daughter is not easy to feed, began by saying, ‘The difficulty I have identified so far is in feeding. She does not like food, so when it comes to eating, it’s so difficult.

How important are health concerns as a factor that affects decisions about what to feed IYC?

To assess this question we asked the full sample of 30 respondents to consider five factors – healthiness; cost; child acceptance of foods; convenience; and ease of acquiring food – and to rank them in order of importance for their decisions about what to give their child. In a subsample, we included another factor – influence of others.

The results of this exercise, presented in Table 5, are striking. Clearly, health trumps everything else. Nearly all mothers chose healthiness as the most important factor they consider in making decisions about food for their children. Only three mothers assigned it to second place (after cost), and no one relegated it to a lower position. Anthropologists use the term ‘cultural consensus’ to describe a situation in which there is a very high level of agreement for a particular value or belief, and there is a technical procedure for calculating levels of cultural consensus (Weller 2004). In anthropological parlance, we can say that there is a ‘strong cultural consensus’ that the ‘healthiness’ of foods is paramount. Whether there is a cultural consensus about the relative healthiness of specific foods is the next issue we examine.

Table 5. Ranking of factors that affect decisions about what to feed

<table>
<thead>
<tr>
<th>Factor</th>
<th>Means (5 is most important)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthiness</td>
<td>4.9</td>
</tr>
<tr>
<td>Child acceptance of food</td>
<td>2.9</td>
</tr>
<tr>
<td>Cost</td>
<td>2.9</td>
</tr>
<tr>
<td>Convenience</td>
<td>2.2</td>
</tr>
<tr>
<td>Ease of acquisition</td>
<td>2.0</td>
</tr>
<tr>
<td>Influence of others</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Are some foods healthier than others?

Underlying the health ranking is the implicit assumption that foods differ in their healthiness. Just how different are they from the perspective of Ghanaian mothers? To address this, we turn to the interview data on women’s ratings of IYC foods for healthiness. To obtain these data, we initially cast a wide net, asking about all of the foods that were elicited during the Free Listing exercise, plus additional cereals and other family foods. We asked all of our respondents to rate food items with respect to healthiness, as well as other qualities on a scale of 1 to 5 (least to most...
Mothers perceive clear differences among the cereal-based foods that are currently available in their environment. There appears to be a basic division into cereals that generally receive high ratings on health and cereals that are generally viewed negatively in relation to their health value. While traditional complementary foods, *koko* and millet porridge (Hausa *koko*), get the lowest ratings, the clear division between high health and low health cereals is not due simply to a rejection of traditional foods in favour of commercially produced items. Traditional foods can receive high ratings on health, actually somewhat higher than commercial foods that are prepared without milk, provided they are augmented with additional ingredients or milk.

One conclusion from Table 6 is that mothers are well aware of the nutritional advantages of milk. Second, it appears that they have been exposed to nutrition messages about the value of adding fish powder, ground roasted peanuts, soy flour and/or oil to traditional *koko*, as ‘home fortified *koko*’ (*koko + †*) in the table) ranks just below Cerelac® with milk (and above Cerelac® prepared without milk).

### Table 6. Ratings of cereal foods (n=30)*

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Health</th>
<th>Child acceptance</th>
<th>Convenience</th>
<th>Cost</th>
<th>Ease of acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerelac with milk</td>
<td>4.8</td>
<td>4.3</td>
<td>5.0</td>
<td>1.1</td>
<td>4.5</td>
</tr>
<tr>
<td><em>Koko + †</em></td>
<td>4.7</td>
<td>4.4</td>
<td>3.8</td>
<td>1.6</td>
<td>3.6</td>
</tr>
<tr>
<td>‘Tom brown home plus’†</td>
<td>4.6</td>
<td>3.5</td>
<td>3.3</td>
<td>2.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Millet porridge with milk</td>
<td>4.5</td>
<td>4.3</td>
<td>4.7</td>
<td>1.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Cerelac with water</td>
<td>4.5</td>
<td>4.3</td>
<td>4.9</td>
<td>1.2</td>
<td>4.6</td>
</tr>
<tr>
<td>‘Tom Brown’ branded flour</td>
<td>4.5</td>
<td>4.3</td>
<td>4.2</td>
<td>2.5</td>
<td>3.8</td>
</tr>
<tr>
<td>‘Tom Brown’ maize flour, home prepared</td>
<td>2.1</td>
<td>3.1</td>
<td>3.2</td>
<td>4.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Millet porridge</td>
<td>2.1</td>
<td>3.4</td>
<td>4.8</td>
<td>4.9</td>
<td>4.4</td>
</tr>
<tr>
<td><em>Koko</em></td>
<td>1.7</td>
<td>3.2</td>
<td>3.6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

*All columns, the best (e.g. Best health, highest child acceptance, lowest cost) is 5 and the worst is 1. †The ‘plus’ indicates ‘home fortification’ with fish powder, ground roasted peanuts, soy flour and/or oil. ‘Tom brown’ is a generic name for porridge that are made from ingredients other than fermented maize (*koko*) or millet (Hausa *koko*). The term covers a range of mixtures from roasted maize flour to multi-ingredient weanimix.

### Table 7. Ratings of non-cereal foods

<table>
<thead>
<tr>
<th>Food</th>
<th>Healthiness</th>
<th>Acceptance</th>
<th>Convenience</th>
<th>Cost</th>
<th>Ease of acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Full sample n = 30)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mpotompoto</td>
<td>4.5</td>
<td>4.1</td>
<td>2.6</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Mashed yam</td>
<td>2.4</td>
<td>3.0</td>
<td>2.8</td>
<td>3.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Tuo zaafi</td>
<td>4.2</td>
<td>4.0</td>
<td>1.5</td>
<td>2.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Banku-okra</td>
<td>4.2</td>
<td>4.1</td>
<td>1.4</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Boiled yam/stew</td>
<td>4.4</td>
<td>3.6</td>
<td>1.8</td>
<td>2.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Cassava-plantain fufu</td>
<td>3.3</td>
<td>2.9</td>
<td>1.1</td>
<td>1.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Boiled rice/stew</td>
<td>3.4</td>
<td>3.9</td>
<td>2.1</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>(Subsample n = 12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice balls</td>
<td>1.6</td>
<td>2.4</td>
<td>3.0</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Rice balls/peanut soup</td>
<td>4.1</td>
<td>3.3</td>
<td>1.3</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Rice and beans/fish</td>
<td>3.1</td>
<td>2.5</td>
<td>1.8</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Boiled plantain/stew</td>
<td>4.6</td>
<td>3.8</td>
<td>2.3</td>
<td>2.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Fried plantain/stew</td>
<td>4.8</td>
<td>4.2</td>
<td>1.7</td>
<td>2.5</td>
<td>2.4</td>
</tr>
<tr>
<td>Jollof rice</td>
<td>3.8</td>
<td>4.0</td>
<td>2.0</td>
<td>1.8</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Ideas about the healthfulness of specific cereal foods, both traditional and commercial, show a high degree of cultural consensus. For example, 28 of 30 respondents gave Cerelac® with milk high ratings (5 or 4 on the scale of 1 to 5), 26 of 30 did the same for Cerelac® without milk. Similarly, *koko*, which has the lowest mean rating of all the cereals, was given a low rating (1 or 2) by 24 of the 30 respondents. There was somewhat less consensus about the negative quality of millet porridge, which rates just above *koko* on the low end of the scale. We conclude that the perceptions about individual cereal foods, like the perception about the importance of health as a factor in what one feeds one’s children, are characterized by strong cultural consensus.

Table 7 shows the ratings of non-cereal foods that are commonly fed to IYC. Many of these are also family foods. The foods in the top half of the table were rated by all of the respondents. The foods in the lower half were rated by a subset of 12 respondents. With the exception of rice balls and mashed yam, the foods are generally given high ratings on healthiness. Women frequently commented that the meat and fish in the stews are excellent sources of nutrients. Typical phrases used to describe these foods include: ‘They are all very nutritious’; ‘They are full of energy and will make them healthy’; ‘These will make them healthy and strong’; ‘Generally the softness of these foods makes them convenient for the baby. They are also very nutritious’; ‘They can easily eat these foods. They are highly nutritious’.

### Why are some foods healthier than others?

#### Nutrition beliefs and knowledge

In the local language, the concept of *ahondene*, which translates best as nutritious, refers to a substance that gives strength. This, in turn, leads to *apondene* (healthy or the state of being healthy). Regardless of their level of education or literacy, the respondents had no difficulty in rating the individual food items on a scale of healthiness. The task intuitively made sense to them. They readily make comparisons among food items with respect to their health value.

From the perspective of our respondents, a fundamental component of healthiness in foods is that they are nutritious. Most of the women used one or more words that are best translated into English as ‘nutritious’. Here is a sampling of the types of comments our respondents made as they rated the specific food items: ‘These foods have no nutrients’, ‘They are all good and nutritious’, ‘Children like them and they are nutritious’, ‘They are highly nutritious’, ‘They are not as nutritious as the others’, ‘These will make them healthy’. Explaining the low rating she assigned for *koko* and millet porridge, a respondent said, ‘The nutrients [in them] are not enough.’

Some women mentioned vitamins in connection with specific foods. For example, Jenny said: ‘Fruits make the children strong and healthy. They also contain vitamins’. When the interviewer asked what vitamins do, she replied, ‘They make us strong and healthy’. Later in the discussion, she commented that Cerelac® contains vitamins.

Maureen, who has a secondary school education and the highest LSM of the women in our study, offered this articulate view of nutrition during an exchange about healthy foods for her 15-month-old son:

**Interviewer:** How would you prepare Albert’s food to ensure that it is very healthy? What would you consider?

**Maureen:** The nutritional value of the food.

**Interviewer:** What nutritional values would you consider?

**Maureen:** It should contain proteins, vitamins, carbohydrates, minerals, fats and water.

**Interviewer:** You mentioned vitamins. What do vitamins do for the body?

**Maureen:** It makes the child grow well.

The concept of vitamins is not part of the conceptual framework about nutritious foods for all of the women. Consider the following exchange with Estelle, the mother of a 7-month-old girl and two other children. After she used the word ‘nutritious’ in connection with a discussion about some complementary foods, the interviewer ask:

**Interviewer:** Have you heard of vitamins?

**Estelle:** No.

**Interviewer:** When you go for weighing [at the child welfare clinic], what ‘drugs’ do they give to Jessica?

**Estelle:** Polio treatment drug and a red drop called vitamin A.
Interviewer: Do you give your child fruits?
Estelle: Yes, especially orange. I squeeze the juice, dilute with water and give it to her by means of a spoon.
Interviewer: Why do you give her orange?
Estelle: It helps prevent constipation.

Another respondent, Ama, the mother of a 15-month-old and another child, gave us this interesting conceptualization of food, fruit and vitamins:

Interviewer: In talking about ensuring the health of your child, you did not mention fruits. Do you give your children fruits?
Ama: Yes, I do.
Interviewer: So why didn’t you mention it?
Ama: We were talking about foods and not fruits. Fruits are not foods.
Interviewer: Why aren’t fruits food?
Ama: Fruits do not give energy. But they protect the children against diseases and make them grow well. Fruits also give free bowels.
Interviewer: What do fruits contain?
Ama: They contain vitamins like E, A, C.

The concept of vitamins also occurred in spontaneous discussions about vitamin supplements in the context of discussing strategies for dealing with poor appetite (see below).

Another dimension of healthiness relates to food hygiene. This idea is reflected, for example, in the following statement: ‘Even if my baby does not like the food, its healthiness is more important. Healthiness of food means it is commercially manufactured like Cerealac® and I (infant formula).’ The cleanliness of food can be achieved through different means. For some women, as expressed in the quotation above, ‘factory-made foods are clean’. Others feel that the only method to ensure the health (i.e. safety) of foods is to make it from scratch themselves. For example, in answer to the question ‘What makes food healthy?’, Patricia said: ‘Food prepared at home because one cannot trust food prepared outside’. For women who hold such views, getting food from vendors on the street is to be avoided. However, others expressed the view that one can buy safe, ready-made convenience foods on the street if you are careful about whom you buy from.

In summary, mothers clearly believe that some foods are healthier than others. The education level of our respondents varied widely from no education to completion of high school. Some of the women are functionally illiterate, and none of them reported reading magazines or newspapers (one of the LSM indicators). Nonetheless, their beliefs about the differential health value of different foods reflect larger concepts about what constitutes healthy food and good nutrition, many of which are closely allied to contemporary nutrition and public health knowledge. Healthy foods are sanitary. Healthy foods are high in nutrients.

Child acceptance of foods

Acceptance comes first, because the child has to eat to be healthy.

Returning to the data in Table 6, we see that child acceptance was ranked equally with cost as a factor that affects women’s decisions about what to give their children. Mothers carefully monitor their children’s reactions to foods and are quick to make changes when a child shows signs of rejecting an item, offering substitutes for the rejected foods. In the discussions about individual food items, virtually all the interviews involved at least passing mention of children’s reactions to particular foods. Moreover, how well or poorly children eat in general – their appetite – was a subject of concern that surfaced repeatedly throughout our interviews. In the course of the study, no respondent ever voiced a concern about lack of availability of appropriate, nutritious complementary foods. On the other hand, a common theme, closely related to child acceptance, was an abiding concern about problematic eating – e.g. rejection of foods, refusal to eat – on the part of children.

Child psychologists emphasize the idea that infant feeding is a two-way process in which infants play a strong role. Some nutritionists and other public health professionals forget this, but mothers do not. In the rating exercise, as well as in their comments throughout the interviews, they frequently reminded us that they are paying attention to how their children respond to the foods they offer.
Managing the logistics of food: cost, acquisition, preparation and convenience

Cost

People give all sorts of advice when it comes to caring for a child, but it is the money I have that will determine what I would buy. (Mary, mother of a 10-month-old and three other children)

During the course of the interviews, nearly all of the respondents voiced concerns about having enough money to take care of their children. The issue of poverty and food insecurity was a thread that was a subtext in the interviews. Two questions were particularly likely to elicit comments about economic resource constraints: (1) a general question on problems parents face in raising children; and (2) a question asking about where and how mothers acquire food. As the nature of the statements was similar regardless of the question that elicited them, we present illustrative examples below:

The major problem is money. Currently, I am jobless so I solely depend on the meager amount of money my husband provides. I have to do a lot of management to keep the family running.

It’s mainly financial issues. I used to sell at the market, but since I gave birth, I have not been able to go, so I am much burdened financially.

Many a time we are faced with monetary problems.

Money does everything. If there is no money, I cannot give my child proper education and provide him with healthy food.

It is worrying because there are times that the food gets finished and it’s like there is no money to buy some at that time.

Interviewer: What major problems do you face in her upbringing?

Respondent: Financial difficulties. I am paid monthly, so sometimes, I enquire money from my husband, and if he also doesn’t have, I turn to my sister for assistance. So generally, money is the problem.

It is clear that having sufficient money to feed and care for their children is a primary concern in the lives of these Ghanaian women. However, as we see in the following sections, Mary’s unidimensional characterization of the determinants of her decisions about infant feeding does not seem to reflect the views of most of the respondents. In addition to food costs and financial resources, cultural factors (knowledge, beliefs and values), child acceptance of foods and issues related to food acquisition and preparation are also important. We examine the latter in the next sections.

Acquiring foods: the matter of control over resources to purchase food

From one culture to another, women’s roles in acquiring foods to feed the family vary widely. In some farming societies, men have the responsibility for growing the food and ensuring that storage facilities are full, while in others, women have a major responsibility for producing food (Goodman et al. 2000). In the former, women typically have little to say about what foods are available to them to prepare meals for their IYC and other family members, although kitchen gardens and/or obtaining meat and eggs from raising chickens or small animals are often exempted from male control (Chatterjee 1989).

Even in many urban communities, men fully control household access to purchased foods, either because they do all of the food shopping or because they control the amount of money a woman has available to make purchases. When women earn money independently of their husbands, they sometimes, but not always, are given control over their funds, and it is often the case that they use their earnings to improve the family diet, particularly the diet of infants and children. The extent to which women have control over household food purchasing varies widely. This generalization applies not only to differences between societies, but is also within them, and it is therefore important to investigate the situation in every community where one wants to understand food purchasing decisions.

To gain insight into food purchasing in Accra with respect to who controls the resources that are necessary to acquire food, we used two techniques: (1) we included ‘influence of others’ as a factor in the ranking exercise of ‘factors that affect what you feed
your IYC’, and (2) we examined this in an exercise in which respondents were asked specifically to compare Cerelac® and tom brown.

In the ranking exercise, ‘influence of others’ had the lowest rank (1.3) and most respondents relegated it to last place (See Table 6). Intriguingly, a number of the respondents were indignant about the suggestions that anyone would influence how they managed the feeding of their infants. They made forceful statements such as: ‘I decide what is best for my child’; ‘I don’t listen to people. I do what is right’; ‘I am not influenced by anyone in anyway’.

On the other hand, the responses in the comparison exercise with the two cereals were more nuanced and revealed a more complex picture of variation within the community. In this exercise, a third of the women chose the highest scale value (5) for the influence of others with respect to their decisions about buying tom brown or Cerelac®. Another group assigned middle levels to the influence of others, and only a minority said that it was not important. Significantly, the women who perceived a strong influence of others usually identified the husband as the influential person, or in one case, it was a sister whose influence was explicitly ascribed to the fact that she supported the family financially. The husband’s role as the person who controls the finances was typically given as the explanation for his influence. For example, one respondent said: ‘My husband has so much influence because he gives out the money for everything’. Apart from the influence that comes from financial control, some women indicated that they seek advice from their mothers. Also, some of the women referred to the advice they receive at the child welfare clinic as a source of influence.

Ease of access and distance as influential factors

Once it has to do with my child’s health, I will do all that I can to keep the child healthy. Distance and time are irrelevant if only the child will eat the food. (Estelle, mother of a 7-month-old and two other children)

Compared with rural areas, urban centres tend to have a high density of places to obtain a wide range of foods. They also have a great range of choices in the types of foods that are available – from ready-to-eat and ready-to-cook foods to basic ingredients. The effects of these characteristics are evident in the massive dietary changes of contemporary urban life. However, access to the diversity of foods one finds in urban areas is not uniform across cities and peri-urban area. A recent and growing literature on food availability in poor neighbourhoods is drawing attention to the fact that, at least in large cities in Europe and North America, constrained availability of some foods, especially fresh fruits and vegetables, is exerting a negative effect on household diets (Larson et al. 2009; Bodor et al. 2010). Poor transportation services and the fact that most poor families do not have cars add to the problem of access (Bostock 2001; Morland et al. 2002).

Given its potential impact on child feeding, it was important to explore issues of access to IYC and household food. To do so, we employed the following techniques: neighbourhood observations; asking about ‘ease of access’ as a dimension in the ratings of IYC foods; and including it in the relative ranking of factors that affect what one feeds to children. We asked direct questions about where our respondents purchased their IYC cereal-based foods and the ingredients for these foods, and we asked a subset of respondents to rank distance as a factor that affects what they feed their children. Additionally, as a check on the oral reports, we asked respondents to draw maps in which they located their residence in relation to the locations of food purchases. We begin here with the respondents’ perceptions about ‘ease of access’ for IYC foods.

In Table 6, we see that the most expensive commercially produced infant cereal (Cerelac®) receives the highest rating for ‘ease of acquisition’ relative to all other foods. In fact, most respondents gave it the top rating of 5. This finding is explained by the fact that most of the small neighbourhood kiosks that dot the landscape offer single-portion packets of Cerelac® for sale. Millet porridge (Hausa koko) follows closely behind Cerelac® in the ease of access rating. This is explained by the fact that it is available, ‘ready to eat’ from the ubiquitous neighbourhood ‘porridge sellers’. ‘Hausa koko’ is made not only for IYC, but it has a large market as the ultimate convenience food for a household.

The cereal that gets the lowest rating is home-fortified tom brown. In this case, the referent is to the various forms of home-prepared weanimix, which are augmented with, e.g. soya flour, ground peanuts and other ingredients that are added to boost its nutritional value. The significantly lower ‘ease of acquisition’ value of this cereal compared with Cerelac® (Chi square = 15.9; \( P < 0.0001 \)) reflects the fact that the additional ingredients are not usually readily available in the urban and peri-urban neighbourhoods.

Compared with the cereals in Table 6, the non-cereal foods in Table 7 are given substantially lower values on ease of acquisition. The mean values in this table mask a range of variation among respondents on ease of access. For example, both banku with okra and boiled yam with kontomire with fish, with means of 2.5 and 2.6, respectively, have bimodal distributions in which about one-third of the respondents are selecting easy access (ratings of 5 or 4), while nearly two-thirds are selecting difficult access (ratings of 1 or 2). It is probable that the differences in the selection of values reflect differences of proximity to large markets and stores from one neighbourhood to another.

Distance is a component of ‘ease of access’. For most people, having to travel a greater distance to obtain a service or goods reduces one’s perception about how easy it is to acquire it. In a subset of 12 respondents, we included distance in the ranking of factors that affect what they feed. The majority of women selected intermediate values for the importance of distance, compared with issues of health and cost. Two respondents gave it a high rank and only two placed it last.

Comparing these rating with those of the two cereals provides another element to the interpretation of the meaning of ‘distance’ and ‘ease of access’. In their ratings of Cerelac® and tom brown, three-fourths of these respondents gave Cerelac® the most favourable rating (5) on distance with a mean of 4.2, while the mean distance value for tom brown was 3.2. These ratings accord with the ‘ease of access’ rating and indicate that the distance one has to go to buy a food relates to perceptions about how easy it is to acquire it.

The maps women drew, in which they located the places where they buy different kinds of food, confirm the generalizations about distance. These showed that kiosks where respondents purchase Cerelac® and the vendors from whom they buy ready-made porridge are uniformly located a short, often very short, walking distance from their homes. On the other hand, most of the women indicated that purchases of ingredients for family foods require a trip by trotro (the local name for the jitney service, which is the major source of public transportation). Typically, women make the trip to large markets once a week. On the maps, some women indicated the location of smaller stores and convenience stores, usually at greater walking distance than the kiosks, where they also make some food purchases. The supplies for making weanimix, or the mix itself, are sometimes obtained at the child welfare clinics, which also involves travel (with the baby) by trotro. A few women reported that a relative (mother or sister) brings them the supplies they need to prepare weanimix.

Regardless of the challenges that women face in providing foods for their children, ‘ease of access’ to foods was ranked as the least important factor that influenced our respondents’ choices about what they feed their children. Similarly, ‘distance’ was also generally downgraded as a compelling factor, and even convenience is not overtly touted as being of primary importance. Some women, such as Estelle (quoted above), felt these were not important influences.

On the other hand, the relationship of acquisition to child caregiving is actually quite complex, and women often articulated the competing pressures they experience, and which they have to manage. Here are some examples: ‘If it is closer, I can get it in time and come back home to do other things. I need time for the children’; ‘A short distance will give me ample time to go and return to do other things’; ‘With weanimix, I have to board a bus to be able to purchase it. With Cerelac®, I just walk to the market to get it. I need time to be able to feed my child and take care of her’; ‘Time is important to ensure that a child is healthy’; ‘My child is like my eye. His health should be my priority. Time is important; distance: I need to get back home in time to cook and take care of my child’.
These poignant, often trenchant, statements capture critical aspects of food management from the perspective of acquisition.

Convenience

Another dimension of food management that is related to issues of ease of access and distance is ‘convenience’. Convenience is a rather global concept, which may be defined differently by different people. For some, ‘convenient’ means you can eat it ‘on the run’. Some people regard foods that are ready to eat and need no refrigeration as convenient. For others, a hallmark of convenience is food that requires no cooking. ‘Convenient’ can also mean readily purchased and requires no planning ahead. With our urban Ghanaian respondents, we did not try to ‘unpack’ their various meanings of convenience. Instead, we asked them to rate foods for ‘convenience’, based on whatever meaning they personally gave to the term. Tables 6 and 7 show the results for the convenience ratings.

Information on food preparation provides additional insights for interpreting the meaning of convenience. We asked respondents to describe their food preparation techniques and procedures for the foods they give their IYC. Here are some examples for koko and tom brown. One woman described her preparation of koko as follows: ‘I bought and steeped the corn myself, then I milled and fermented it. I took a portion of the dough, mixed it with some water and cooked in boiling water while stirring.’ Another said, ‘I sieved the mixed corn dough, then I cooked it with whintiaa. Before that, I bought corn and soaked it for milling’. A typical report on the preparation of tom brown (weanimix) was supplied by Mary: ‘I milled some roasted corn, soya beans and groundnuts to get the tom brown, then I mixed some with water and cooked in boiling water, stirring till cooked. After I added some milk and sugar.’

In contrast to the preparation methods for cereals that require cooking, the description of Cerelac® preparation was uniformly short and simple. Twenty-one of the 30 respondents included a description of the preparation of Cerelac® in their narratives. Virtually everyone said they emptied the content of a packet into a bowl and added water; two women noted that they use ‘hot water’. 14 women said the water was ‘warm’, one woman described the water as ‘cold’ and four of the respondents did not specify the water temperature. It is not clear whether the water is heated to boiling and cooled or just warmed.

When it comes to convenience, only one food from the total of 22 foods in Tables 6 and 7 universally received the same rating, and the highest rating: Cerelac® with milk. Cerelac® prepared with water did almost as well, with a mean rating of 4.9. Next in line, with convenience means of 4.8 and 4.7, respectively, were millet porridge and millet porridge with milk. Notably, for the cereals, the lowest mean ratings on convenience were for home-prepared tom brown and home-fortified tom brown.

The explanation for the exceptionally high rating and total agreement on Cerelac® involves several factors. The packets can be obtained quickly and easily from neighbourhood kiosks. The product is sold in large tins, but also in small packets, and although the price per unit of weight is high, individual packets can be purchased with a small cash outlay. Another aspect of convenience is that it requires no cooking over fire. Although the majority of the women use warm or hot water, this is often water that has been stored in a thermos. Women do not have to heat up a charcoal brazier to prepare Cerelac®. It can literally be purchased and fed ‘on demand’. Thus, it qualifies as a ‘convenience food’ par excellence. Millet porridge is also very convenient because it can be purchased ready-made from a koko seller, and sellers are also usually to be found very close to home.

The non-cereal foods routinely receive low ratings on convenience. Of all the items elicited from the initial free listing of complementary foods for IYC, the popular tuozaafi (maize/cassava flour cooked into very thick porridge-like paste) and banku (fermented maize and cassava dough cooked into thick paste/dumpling) with okra were given particularly low ratings on convenience. The descriptions women gave about their long and complex preparation techniques for these foods provide a clear explanation for these ratings. None of the food items in Table 7 are viewed as convenient. Even home-prepared tom brown, which had the lowest convenience mean of the por-
ridge, was marginally better than rice balls, the most convenient non-porridge infant food.

Conclusions

The purpose of this paper is to present a picture of the general patterns of complementary feeding behaviours in urban Ghana. The use of an ethnographic approach provides insights not only into what caregivers are giving, but also the factors that underlie their behaviours. Clearly, developing statistically supported assessments of these factors in order to accurately describe variability within the population, to obtain the statistical distributions of these variabilities and to examine their relative importance as determinants of behaviour requires other methods and other data.

In the study, we found that economic constraints are critical, and cost is a primary concern. This is not ‘news from the front’. In fact, this is what everyone would expect. What is compelling is the finding that from the caregivers’ perspective, the healthiness of the foods they give their children is also of primary importance. From their perspective, all foods are not equal and individual foods differ considerably with respect to their ‘healthiness’. Providing foods that promote health is a central motivation. This creates difficult problems for caregivers because the cheapest foods are not seen as the healthiest ones. When mothers feed low-cost, traditional porridge, they feel that they are not giving their children the best foods for their health.

Beliefs about the healthiness of foods are part of a larger complex of motivation that can be described as ‘nurturance’. The New Oxford American Dictionary defines nurturance as ‘emotional and physical nourishment and care given to someone’ and ‘the ability to provide such care’. In this case, nurturance involves not simply the mothers’ ideas about foods for health; it includes a complex of beliefs and practices aimed at furthering the health, well-being and development of children. The voices of the mothers we have included in this paper provide glimpses of this larger complex and its continuous importance for the women we talked with.

Balancing the two competing determinants – cost and nurturance – would be challenging enough, particularly when one considers the social constraints to decision-making that many women face, particularly in relation to other adults in the household, primarily male partners. But we found that a third sector of determinants also plays a central role in the caregiving/feeding equation – namely issues of time management. These can be summarized by the concept of ‘convenience’. As discussed above, this is a complex notion that involves several different elements related to women’s time management. The multiple demands on women’s time, and the various ways in which they cope with these competing demands, has been a matter of increasing interest and concern in many sectors, ranging from social welfare and social action institutions to commercial activities and markets, as well as social and political analysts and investigators.

Convenience, as such, is not accorded a high place in the Ghanaian caregivers’ explicit value systems. But its importance for their decisions about what to feed their IYC feeding is implicit in their behaviours, and in what they say about the challenges of time management. They have to make difficult choices in which saving time for activities other than acquiring and preparing food for their IYC is often important, so important that they are willing to forego other demands on their scarce financial resources.

Nurturance, cost and time are the three vectors of complementary feeding behaviour in urban Ghana. Are these three vectors uniquely applicable to urban Ghana, or are the dynamic interactions among them operating in other cultures and environments? We suggest that this is a fruitful area for research on complementary feeding behaviour and its determinants.

Acknowledgements

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Sources of support

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Conflicts of interest

None.

References


Abstract

The objective of this formative research was to assess the acceptability of a micronutrient powder (Sprinkles®) and a lipid-based nutrient supplement (Nutributter®), and to explore people’s willingness to pay for these products in a resource-poor context like Niger. In four sites, 84 focus group discussions among mothers, fathers and grandmothers of children 6–23 months were conducted, as well as 80 key informant interviews of mothers who participated in a home study where their children 6–23 months were given either Sprinkles® or Nutributter® to use either for a period of 4 weeks, or they were given both products over the 4-week period, i.e. Sprinkles® for 2 weeks and Nutributter® for an additional 2 weeks. The mothers understood how to use the products and generally used the products correctly. Both products were highly acceptable to adults and most children. In Niamey, where the 4-week home study used both products for 2 weeks each, the mothers tended to prefer Nutributter®. The mothers who used either product were pleased with the improvements they saw in their children’s health, including increased appetite, weight gain and increased energy and activity. A few mothers were concerned with how they would be able to provide for their child’s increased appetite. Most participants across all four sites reported that they would be willing and able to afford to buy a single sachet of either Sprinkles® at a cost of US$0.03 or Nutributter® at a cost of US$0.08 several times a week. This study provides evidence that both of these products were highly acceptable in different settings in Niger and suggests that delivery of Nutributter® or Sprinkles® at a low or subsidized cost through a market-based system may be possible in Niger, if an appropriate distribution system can be identified.

Keywords: micronutrient powder, lipid-based nutrient supplement, Niger, undernutrition, formative, acceptability, market-based.

Introduction

Inadequate nutrition among young children is a significant global public health problem, with more than one-third of deaths among children under the age of 5 years due to undernutrition (Black et al. 2008). Among children that survive, undernutrition has long-term consequences including growth faltering, lower educational attainment, reduced economic productivity and poorer reproductive outcomes (Victora...
The key period for intervening to promote optimal growth and development of a child is throughout pregnancy and during the first 2 years of life (Victora et al. 2010). The World Health Organization recommends exclusive breastfeeding until 6 months of age, at which point, breast milk alone is no longer sufficient, and diverse complementary foods need to be introduced in addition to continued breastfeeding (WHO 2002). Throughout the developing world, access to nutritious, energy-dense complementary foods is generally limited.

Several products have been developed to increase the nutrient intake of young children 6–23 months of age. These include micronutrient powders (MNPs), such as Sprinkles®, and lipid-based nutrient supplements (LNSs), such as Nutributter®. MNPs have no taste or colour, which results in the ability to feed children the product without their knowledge. The wholesale cost of a sachet of MNP typically costs about US$0.02 per day1. A systematic review of efficacy studies showed that Sprinkles® is very effective at reducing iron deficiency, and decreases the prevalence of anaemia by half (Dewey et al. 2009). Sprinkles® has not been shown to have a significant effect on growth but has been shown to have an effect on motor development, as evidenced by an increased prevalence of children walking at 12 months of age (Adu-Afarwuah et al. 2008).

Nutributter® differs from Sprinkles® in that it provides energy, fat (including essential fatty acids) and protein, in addition to micronutrients. A daily serving of Nutributter® (20 g) provides about 100 calories, which is approximately one-half to one-quarter of the calories needed from complementary foods for a breastfed child aged 6–23 months (Chapparro & Dewey 2010). Nutributter® has a sweet peanut taste, so it will affect the taste of any food that it is mixed into; additionally, it can be eaten alone. A serving of Nutributter® is more expensive than Sprinkles®, at a wholesale price of approximately US$0.08 per day2.

In Niger, the mortality rate for children under 5 years is one of the highest in the world, at 198 deaths per 1000 live births. Among children 6–23 months, 91% are anaemic, 49% are stunted and 18% are wasted (National Institute of Statistics and Macro International Inc 2007). Entirely free programmes are increasingly unsustainable due to limited government and donor funds, and other approaches are needed to support nutrition interventions. Multiple partners were interested in investigating the possibility of establishing a market-based distribution of micronu-

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Key messages

- Deficiencies of macro- and micronutrients among young children in Niger are a public health concern. Strategies are needed to improve the nutritional adequacy of complementary foods in addition to supporting exclusive breastfeeding for children 0–6 months of age and continued breastfeeding for at least 2 years.
- Nutributter® was the preferred product, although both Sprinkles® and Nutributter® were well accepted by children 6–23 months and their mothers during a 4-week home study. The focus group participants also liked both products but tended to prefer Nutributter®.
- Participants of the 4-week home trial and also the focus groups across all four sites were prepared to pay several times a week for the products.
- Future studies should look at the use of home fortificants and their interaction with infant and young child feeding practices.

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1The cost of a sachet of Sprinkles® tends to range from US$0.015 to US$0.035 depending on volume produced and site of production – http://www.sghi.org/about_sprinkles/about_sprinkles.pdf

2One 20 g sachet of Nutributter® is estimated to cost US$0.08 (M. Zeilani, personal communication).
trient supplements designed for preventing undernutrition among young children. Before developing such a programme, extensive formative work was needed for several reasons: (1) to update ethnographic work on infant and young child feeding; (2) to assess if Sprinkles® and Nutributter® were acceptable to the population and if there were any problems with use; (3) to explore whether families would be willing to purchase preventive health items for young children given families are accustomed to receiving free health services for children under 5 years of age; and (4) to explore possible channels for a market-based distribution. The purpose of this paper is to describe the results of the formative work related to the acceptability of the products and the willingness of users to pay for these products in a market-based system.

Methods

Location

Four sites with different levels of urbanization were chosen within two primary locations. Within Niamey, the capital, two sites were selected; Gamkalley, an urban industrial area, and Goudel, a peri-urban area where residents tend to be involved in some agricultural activities. In both of these sites, Djerma is the predominant language used. In the second location, the district of Dogondoutchi in the Dosso region, Doutchi city and Soucoucouitane village were selected, in order to get representation of a larger town and a very dry rural village, respectively. The predominant language spoken there is Hausa, which is the principal language in Niger.

Qualitative data collection

Data collection occurred from July to November 2009. Purposive sampling was used to identify the primary target groups: mothers, fathers and grandmothers of children 6–23 months of age. In each study site, qualitative data collection techniques included focus group interviews, key informant interviews and observations. All participants gave informed verbal consent. After the informed consent, but before the interviews began, demographic data were collected from all participants. Bilingual or multilingual-trained female data collectors conducted all interviews in either Djerma or Hausa. During the interview, notes were written in French as Djerma and Hausa are not generally written languages. The French notes were later translated into English by a professional translation company.

The content of seven focus group interview guides tailored for the three target groups centred on health, nutrition and feeding practices of young children; household dynamics related to resources’ decision making and spending priorities; and reactions to the two products including taste, first impressions and cost (Table 1). For each topic and target group, three focus group interviews with five to eight participants each were carried out in each of the four sites, resulting in a total of 84 focus group interviews.

Additionally, a 4-week home study was conducted among 20 households with children 6–23 months of age in each of the four sites, for a total of 80 households. All children 6–23 months within the selected household were eligible to participate. A household list was drawn up in each of the four sites, and households were
selected based on gender, age, and demographic and geographical characteristics so that the households would be the representative of their community. The mothers were the respondents in key informant interviews conducted at enrolment, midpoint and end of the home study. A household observation of mothers using the product was also conducted during the midpoint visit. In each of the two sites in Doutchi, the mothers received either Sprinkles® or Nutributter® but not both, to use daily for 4 weeks. In each of the two Niamey sites, a crossover design was used, where participants were given both Sprinkles® and Nutributter® to use for 2 weeks each. To ensure that the order in which the families received the products did not affect their impressions, the half started with Sprinkles®, while the other half started with Nutributter®. The two different methods were used in order to allow some mothers a longer time to experience the products (Doutchi), while others would be able to directly compare the products (Niamey).

Regimen and product information given to participants of the focus group interviews and the 4-week home study

In both the focus group discussions and in the 4-week home study, participants were given information about the composition of the products. The field workers read the following statement to the participants regarding Sprinkles®: ‘Sprinkles® are a fine powder that contains several vitamins and minerals that can be mixed into a child’s food’; and regarding Nutributter®: ‘Nutributter® is a peanut-based spread that is made from peanuts, oil, milk powder and sugar. It also contains several vitamins and minerals. Nutributter® can either be eaten on its own or it can be mixed into food’. For both products, participants were informed that Sprinkles® and Nutributter® have been used in various countries to reduce children’s anaemia, increase their appetite, increase their energy and, generally, improve their health.

During enrolment into the 4-week home study, field workers demonstrated how to use the product, including opening the products and mixing them into a small quantity of food, and explaining that the food mixed with either product should best be used within 30 min of mixing. The mothers were also instructed that Nutributter® could be given directly without mixing it into food.

Due to concerns that supplemental iron may exacerbate infections, particularly malaria, in iron-sufficient children, and that folic acid may interfere with the efficacy of antifolate, anti-malaria therapy (WHO Secretariat on behalf of the participants to the Consultation 2007), the Sprinkles® and Nutributter® formulations used in this formative work were modified to reduce iron content and remove folic acid. The amount was reduced to be similar to supplying what would be found in normal complementary foods. Table 2 shows the nutrient content for both products. As a result of this change in the formulation, a twice-daily regimen for the products was used, in contrast to previous studies that gave more iron and used the product only once per day. For Sprinkles®, the mothers were instructed to mix one sachet into their child’s food twice per day (two sachets per day total). For Nutributter®, mothers were instructed to either mix into food or give directly to their child one sachet per day, splitting the sachet so as to give half in the morning and half in the afternoon or evening.

For both products, participants were given detailed information and demonstration on how to use the products. They were also advised that they may notice their child’s stool becoming darker or that he or she has loose stools for a few days, which was normal.

Data management and analysis

English transcripts of all data were uploaded into Nvivo 8 (QSR International, Cambridge, MA, USA). Three authors (K.T., C.P. and B.H.) read all the transcripts and coded and analysed the data. Interviews were first coded by questions and then for key themes. At least two authors coded and analysed each section of data, and the discrepancies were resolved by discussion. Key quotes were identified that represented the majority’s view. Analyses were initially stratified

3The Sprinkles® used in this study was manufactured by Hexagon Nutrition, Mumbai, India.
4The Nutributter® used in this study was manufactured by Nutriset, Malaunay, France.
by site and target group; and results were combined where there was little difference across sites, and unless otherwise noted, results being presented were found to be consistent across sites.

**Ethical review**

Ethical approval was obtained from the Niger Ministry of Health. Additionally, the United States Centers for Disease Control and Prevention determined that the project was consistent with the standards for public health practice.

**Results**

In total, 84 focus group discussions were held with a combined total of 232 mothers, 130 fathers and 147 grandmothers.

The average age of all mothers participating in the focus group discussions was 27 years (range 15–47). The majority had no primary education. Ninety-three per cent of mothers were married, of which, 28% were in a polygamous marriage. The average age of fathers was 39 years (range 24–65); all were married and 19% were polygamous. The average age of grandmothers was 58 years (range 30–110).

Key informant interviews were conducted with 80 mothers who participated in the 4-week home study. Of these, 77 completed all three interviews at enrolment, midpoint (plus observation) and exit. Of the 83 children enrolled in the 4-week study, 36 were between 6 and 12 months of age (Table 3).

**Purchase of special items for young children**

Many families do buy foods or treats specifically for young children that are apart from the family bowl or what is given to older children. The money usually comes from the father, but if the father does not have money, many mothers do have some form of income generation, such as extraction of peanut oil or selling fritters, and they will use this money to buy foods for young children. The foods purchased for young children include Solani (liquidy yogurt), bean fritters, bananas, potatoes, eggs, cookies, oranges and canned milk. Families, especially in both Niamey sites and Doutchi city with access to vendors, often buy these small quantities of food multiple times throughout the day, with the cost of each item usually ranging from 25 CFA to 125 CFA (US$0.06–US$0.25). The reason they gave for buying these foods for young children was to promote the child’s growth, health and nutrition.

### Table 2. Nutrient composition of Sprinkles® and Nutributter® used in this study

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Sprinkles® (total per day – two sachets)</th>
<th>Nutributter® (total per day – 1 x 20 g sachet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (vitamin A acetate)</td>
<td>300 mcg</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>Vitamin B1 (thiamin mononitrate)</td>
<td>0.5 mg</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>Vitamin B2 (riboflavin)</td>
<td>0.5 mg</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>Vitamin B6 (pyridoxine)</td>
<td>0.5 mg</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>Vitamin B12 (cyanocobalamin)</td>
<td>0.45 mcg</td>
<td>0.5 mcg</td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>35 mg</td>
<td>30.0 mg</td>
</tr>
<tr>
<td>Niacin (niacinamide)</td>
<td>6.0 mg</td>
<td>4.0 mg</td>
</tr>
<tr>
<td>Copper (copper sulphate)</td>
<td>0.6 mg</td>
<td>0.2 mg</td>
</tr>
<tr>
<td>Iodine (potassium iodide)</td>
<td>50 mcg</td>
<td>90.0 mcg</td>
</tr>
<tr>
<td>Iron (ferrous fumarate)</td>
<td>6.0 mg</td>
<td>4.5 mg</td>
</tr>
<tr>
<td>Zinc (zinc gluconate)</td>
<td>5.0 mg</td>
<td>4.0 mg</td>
</tr>
<tr>
<td>Vitamin D3 (cholecalciferol)</td>
<td>5.0 mcg</td>
<td>–</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>6.0 mg</td>
<td>–</td>
</tr>
<tr>
<td>Selenium</td>
<td>–</td>
<td>10.0 mcg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>–</td>
<td>16.0 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>–</td>
<td>100.0 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>–</td>
<td>82.1 mg</td>
</tr>
<tr>
<td>Potassium</td>
<td>–</td>
<td>152.0 mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>–</td>
<td>0.08 mg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>–</td>
<td>1.8 mg</td>
</tr>
<tr>
<td>Energy</td>
<td>–</td>
<td>108 Kcal</td>
</tr>
<tr>
<td>Proteins</td>
<td>–</td>
<td>2.6 g</td>
</tr>
<tr>
<td>Fats</td>
<td>–</td>
<td>7.1 g</td>
</tr>
</tbody>
</table>

*20 g of Nutributter® also provides a minimum of 1.29 g Linoleic acid and 0.29 g alpha-Linolenic acid.
other preventive health products available in the village.

**Product acceptability**

Both Sprinkles® and Nutributter® were found to be acceptable and beneficial in all four sites. At the end of the home study in Doutchi, where mothers used only one of the products for the entire 4 weeks, all mothers liked the product that they used and would continue to use that product if it were available locally.

In response to Sprinkles® one mother said, ‘I saw the usefulness of Sprinkles® and I would recommend all mothers look for it for their children. And if it is possible, we would like it to be available on the market as soon as possible’ (Mother in Doutchi, 4-week study). Mothers said that Sprinkles® was easy to use, and several liked that the product had no taste or smell and did not change the taste of the food. A barrier that was encountered to using Sprinkles® is that food is required for the Sprinkles® to be mixed into. In Soucoucoutane, there were instances where a mother was not able to give her child Sprinkles® because she simply did not have any food.

Regarding Nutributter® a mother said, ‘all that I want to say is to thank you for having given our children these very important foods. Really, we saw its importance and we appreciate it a lot’ (Mother in Soucoucoutane, 4-week study). Few participants found Nutributter® unacceptable.

For both products, a few mothers mentioned that they disliked the fact that their children had loose stools in the first few days of use. However, most also said that because they were warned about this side effect, they were not concerned.

Overall, there were very few concerns for either product. When asked if the participants had any questions or concerns about using the products, the topics raised regarding the use of Sprinkles® and Nutributter® are presented in Table 4.

**Perceived effects of products**

Participants in the home study reported noticing changes in their children within the first 2 weeks of using Sprinkles® and Nutributter®. In Doutchi, where children only used one product for the entire 4 weeks, the same effects were noticed by mothers of children using Sprinkles® and those using Nutributter®. Almost all mothers in the home study in all sites, regardless of the product they used, reported some increase in appetite or weight gain in their child. ‘Before I bought my daughter boule [millet-based porridge] for 25 CFA [US$0.06 at the time of the study] for the whole day, but with the use of Sprinkles® she eats boule for 50 CFA [US$0.12] a day’ (Mother in Goudel, 4-week study).

Many mothers reported that the weight gain in the child was noticed not only by themselves, but also by family and community members. Describing the weight gain of her daughter, one mother said, ‘At first when she was 5 months she weighed 3 kg. Then [my husband] did not pick her up because she was all lean. But now since she has gained weight he always picks

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**Table 3.** Characteristics of 80 mothers and 83 children participating in the 4-week home study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dogondouchi Douchi</th>
<th>Soucoucoutane</th>
<th>Niamey Goudel</th>
<th>Gamkalley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age of mothers (years) (range)</td>
<td>30.5 (19–45)</td>
<td>25.7 (16–40)</td>
<td>33.1 (21–48)</td>
<td>26.9 (18–37)</td>
</tr>
<tr>
<td>Mean age of infants (months)</td>
<td>13.2</td>
<td>12.7</td>
<td>13.6</td>
<td>16.2</td>
</tr>
<tr>
<td>Number of infants 6-11 months of age</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Mean HH size</td>
<td>9.0</td>
<td>11.0</td>
<td>8.7</td>
<td>7.9</td>
</tr>
<tr>
<td>Received primary education %</td>
<td>55</td>
<td>10</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>Polygamous marriage %</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Work outside the home %</td>
<td>75</td>
<td>40</td>
<td>55</td>
<td>35</td>
</tr>
</tbody>
</table>

HH, (Household), the basic residential unit in which activities are organised and carried out.
her up’ (Mother in Gamkalley, 4-week study). Mothers also reported that they noticed increased energy and strength in their children, and that their children were more likely to interact and play with other children.

Several mothers reported that at the start of the study, their child had darker stools and some mild diarrhoea. Most said that this did not worry them as they were told that this might happen. Some mothers felt that the diarrhoea was a sign that the products were working and that the body was getting rid of ‘bad blood’. Overall, the reported changes were perceived as very positive even though a few mothers were worried about where they would get enough food to satisfy their child’s improved appetite.

**Twice-daily use**

No mothers reported having any trouble remembering to give the products twice daily. All mothers with children enrolled in the home study understood either to give two sachets of Sprinkles® per day or to split the sachet of Nutributter® into two daily doses. The mothers did not like having to split a single sachet of Nutributter® into two doses as they felt that it was difficult to correctly portion out half of the sachet, and they felt that it was unhygienic to leave the sachet open for the day. The mothers who gave their child Sprinkles® twice a day were asked if they would prefer a single administration per day rather than two, independent of cost implications. Most mothers said that they would rather give two a day. Some commented that if the child wasted some food with the Sprinkles® in it, they felt relieved that they would be able to give their child more Sprinkles® later in the day. However, a few mothers felt that one sachet per day would be easier to remember.

**Feeding practices**

Many of the children enrolled in the 4-week study ate boule (millet-based porridge), and some also ate from the family dish. Many mothers also reported preparing special foods for their child such as bean soup, eggs, fritters, fruit and occasionally, pasta, rice and entrails. Nearly all mothers of children enrolled in the home study reported that their child already had their own bowl prior to the study and that they were generally fed from an individual bowl vs. the communal bowl. Few mothers had to buy or borrow any additional equipment to utilize either the Sprinkles® or Nutributter®; nine of the 59 participants (15%) that used Sprinkles®, and three of the 56 participants (5%) that used Nutributter® at some point in the 4-week study said that they had to purchase something to be able to use the product. The items purchased included bowls, plastic cups, spoons and ladles. Mothers reported that bowls cost about 125 CFA (US$0.22), and spoons were about 50–75 CFA (US$0.09–US$0.13). All the mothers thought that this cost was acceptable and affordable for most families.

**Observation of actual use of products**

**Nutributter®**

During the home study, 37 mothers who received Nutributter® were observed in the household feeding

---

**Table 4. Questions/concerns about use of Sprinkles® and Nutributter® among mothers participating in the 4-week home study**

<table>
<thead>
<tr>
<th>Questions asked about both products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it necessary to take my child to the health centre if their soft stools/mild diarrhoea persists?</td>
</tr>
<tr>
<td>What would happen if my child consumed too much of the product at one time?</td>
</tr>
<tr>
<td>Will my child’s health suffer when the study ends and there are no more products?</td>
</tr>
<tr>
<td>Will using the product prevent anaemia even if the child becomes sick while using the product?</td>
</tr>
<tr>
<td>What will happen if I forget to give my child the product every day?</td>
</tr>
<tr>
<td>What will happen if I give my child food mixed with the product after 30 mins has passed?</td>
</tr>
<tr>
<td>Where can I buy more and how much will it cost?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions asked about Sprinkles®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can Sprinkles® make the body swell?</td>
</tr>
<tr>
<td>Can I give my child two sachets in one meal?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions about Nutributter®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you give one bag in one go rather than splitting it?</td>
</tr>
<tr>
<td>Will my child’s increased appetite continue once the Nutributter® is finished?</td>
</tr>
</tbody>
</table>
their child. Most mothers opened the sachet using a razor blade, their teeth or scissors. Most children who were fed Nutributter® directly were given it on a spoon, from their mothers’ fingers or squeezed onto the child’s hand. Most mothers gave the right amount of Nutributter®; only one mother gave the child more than the instructed half of the sachet. One mother gave a little of the Nutributter® to an older child who was asking for some. All children who ate the Nutributter® mixed into food were given the food immediately after the Nutributter® was mixed in. Of the 16 children who had Nutributter® mixed into their food, four did not finish the food mixed with Nutributter®. Only 2 of the 21 children eating it directly refused to finish all the Nutributter®.

Sprinkles®

Of the 38 mothers who were observed using Sprinkles®, three children refused to eat their food mixed with Sprinkles®. Nearly all of the mothers used the Sprinkles® correctly, mixing the whole sachet into a small quantity of food in bowl or cup and feeding it to the child immediately. In Soucoucoutane, one mother used a sachet of Sprinkles® that was already opened; one mother prepared the Sprinkles® with a very dirty spoon; and one mother used a very dirty cup. All of the children were fed the food immediately after the Sprinkles® had been added.

Intention to use and reported use of Nutributter®

At the beginning of the home study, mothers were asked how they intended to give Nutributter® to their child. Most mothers said that they intended to mix it into boule or some other kind of food. Several mothers also said they would give it to their child directly because their child liked sweet foods. A few mothers said that they would try it both ways and see which way the child preferred.

Of 37 households with Nutributter® available on the day of the observation visit, 21 children were given the Nutributter® directly and 16 children had it mixed into their food. Of the 37 households, 18 children were between 6 and 12 months of age. Of those 18 children, 10 were given the product directly and eight had it mixed into their food. Four out of the 18 children did not finish their Nutributter® or boule mixed with Nutributter®.

The results from the interviews at different time points revealed that although most mothers had intended to mix the Nutributter® into food, more mothers ended up giving the Nutributter® directly. Several mothers reported that they started feeding the child Nutributter® one way and then changed. The main reasons mothers gave for changing from direct feeding to mixed with food are as follows:

- child refused the Nutributter® directly; and
- child could not eat it easily alone.

The main reasons for switching from mixed with food to direct feeding are as follows:

- child refused boule with Nutributter®;
- child prefers to eat Nutributter® directly;
- child did not finish boule and Nutributter® was wasted; and
- it was easier for the mother to just give the Nutributter® to the child to feed himself.

Sharing and pressure to share

During the course of the 4-week study, several women experienced pressure to share either Nutributter® or Sprinkles®. Women in both sites in Doutchi seemed to experience more pressure than women in the two Niamey sites. Pressure to share was mainly from older children in the household and neighbours. In a few houses, the co-spouse and other family members also pressured the mother to share. During the course of the observations, the field workers also witnessed several instances where women were pressured to share. Most women did not share and told those pressuring her that the sachets were counted and were for her child only. Overall, five of the 80 mothers reported giving product away to other people, this included both Sprinkles® and Nutributter®. In two households, some of the products were stolen from the household.

Product preferences

In the two Niamey sites, children enrolled in the 4-week study were given a 2-week supply of
Sprinkles® and a 2-week supply of Nutributter®, irrespective of the order of receiving the products, the majority of mothers (27 out of 37, 73%) said that if they were given the opportunity to select a product to continue using, and if it was to be given for free as it was in the home study, they would select Nutributter®. Ten mothers selected Sprinkles®. Out of the 37 mothers who responded to the question on product preference, 15 had a child between 6 and 12 months of age. Of those 15 mothers, 13 preferred Nutributter®, and two preferred Sprinkles®. One mother said she would select Sprinkles® because it was cheaper than Nutributter®, the other said that she would select it because the child would not realize that it had been mixed into the family dish. The main reasons the participants in the two Niamey sites gave for preferring one product over another is presented in Table 5.

When asked which product they would buy if both products were available on the market, the majority of women still selected Nutributter® (25 out of 37). However, two mothers who had said they preferred Nutributter® said they would choose to buy Sprinkles® because it is cheaper.

**Distribution locations**

When asked where Sprinkles® or Nutributter® should be sold, a variety of answers were given. The primary places that people mentioned were pharmacies and health centres. Both of these were described as places that could be trusted not to sell expired products, and where the products would be protected from heat and dust. Additionally, pharmacies were described as places where set prices could be counted on; and health centres are where mothers are used to receiving counselling about child feeding and nutrition.

**Willingness to pay**

**Nutributter®**

At the end of the home study, mothers were asked how much they would be willing to pay for a sachet of Nutributter®. The reported median price mothers in Niamey were willing to spend was 100 CFA (US$0.22, range US$0.05–US$1.05), and 50 CFA (US$0.11, range US$0.02–US$0.63) in Doutchi. When asked if they thought that 35 CFA (US$0.08) was a reasonable price for a sachet of Nutributter®, 54 out of 57 (95%) mothers who had used Nutributter® said they would be willing to purchase Nutributter® at that price.

**Sprinkles®**

Mothers who used Sprinkles® during the home study were asked how much they would be willing to pay for a sachet of Sprinkles®. The median reported that the price in Niamey was 50 CFA (US$0.11, range US$0.050–US$1.05), and 25 CFA (US$0.06, range US$0.02–US$0.73) in Doutchi. When asked if they thought that 15 CFA (US$0.03) was a reasonable price for a sachet of Sprinkles®, reminding them that it was recommended to use two sachets per day, 57 of 58 (98%) said they would be willing to purchase it at that price.

There was no marked difference between what people were willing to pay for either product after trying the product in the home study compared with just seeing a demonstration of the product during the focus group discussions. Most women said that they would either ask their husbands for money to pay for the product or use their household money or the money they generated themselves from their small business. Women in Doutchi city said that they would use their own money to buy the products more often than women in the other sites.

### Table 5.

Among mothers who used both Sprinkles® and Nutributter® for 2 weeks each, these are the reasons the participants gave for preferring one product over the other.

<table>
<thead>
<tr>
<th>Primary reasons for selecting Nutributter®</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet taste that the child liked</td>
<td></td>
</tr>
<tr>
<td>Ability to either mix the product or use directly</td>
<td></td>
</tr>
<tr>
<td>Nutributter® worked better than Sprinkles®</td>
<td></td>
</tr>
<tr>
<td>The child can eat it by himself</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary reasons for selecting Sprinkles®</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>There is no taste and can be mixed into the family food without the child knowing</td>
<td></td>
</tr>
<tr>
<td>Sprinkles® worked better than Nutributter®</td>
<td></td>
</tr>
<tr>
<td>Child refused Nutributter®</td>
<td></td>
</tr>
</tbody>
</table>
Stores and street vendors appealed to some because they are prolific, and even young children could be sent with money to purchase the product. Larger stores were also described as appealing because they were protected from the elements. A few participants suggested having the chief of the area or village sell the products as he is a respected authority figure, and everyone knows where he lives and could go for more products.

Most people said that they would be willing to travel up to 5 km to buy either Nutributter® or Sprinkles® but that it would be difficult to travel more than 5 km on foot. People who could afford to take taxi motorbikes were prepared to travel much further (15–20 km).

**Discussion**

Overall, most participants in the focus group discussions and 4-week home study were enthusiastic about both Sprinkles® and Nutributter®. Several other studies have also found Sprinkles® to be acceptable to parents and children (Christofides et al. 2006; Adu-Afarwuah et al. 2008; Jefferds et al. 2010), with less data available for Nutributter® as it is a newer product (Adu-Afarwuah et al. 2010; Hess et al. 2010). In the present study, mothers using the products were particularly pleased with the improvements they saw in their children’s health. For both products, almost all mothers perceived that their child had an increased appetite and had gained weight, and many also commented on their child’s increased energy and activity. A few mothers were concerned with how they would be able to provide for their child’s increased appetite. However, overall, these changes in appetite were considered very positive. Similar concerns with increased appetite have been reported during formative research for a market-based Sprinkles® intervention in Western Kenya, where increases in household food costs due to increased appetite turned ‘a positive and valued effect into a potential problem’ (Jefferds et al. 2010). However, after 8 months of implementing the Sprinkles® study in Western Kenya, monitoring data showed that this was not a widespread problem as only 5% of mothers reported that increased appetite was a barrier to Sprinkles® use (Jefferds et al. 2009).

The results from this formative work suggest that even though this Nigerian population is very poor, some people are willing to buy products like Nutributter® and Sprinkles® for their children. Dewey found similar results in a study comparing three fortified products in Ghana (Dewey et al. 2009), suggesting that in some populations, people would be willing to purchase small quantities of products needed for in-home fortification. One possible weakness of this study is that the participants were informed about some of the potential benefits of the products, including increases in appetite and activity, and a reduction of vitamin and mineral deficiencies, and this may have affected some people’s perceptions about the products and their willingness to pay. Despite this, it was felt necessary to provide some general information on their use so that participants would not fear using the products or think that the products were being tested on them.

Most families across all four sites reported that they would be able to afford to buy Nutributter® at a cost of ~US$0.08 or Sprinkles® at a cost of ~US$0.03 several times a week. Families in Soucoucoutane, the most rural site included in the study, were also willing to buy the products. However, when asked how much they would be prepared to pay on a daily basis, they tended to propose a unit price that was lower than those proposed in the other sites and said that they would purchase the product when they were able to, but that they did not always have extra money. Soucoucoutane is a more rural and food-insecure part of Niger and resembles the majority of the country more closely than Niamey. If a market-based system was to be established, prices may need to be subsidized for the poorest families or for people living in the poorest areas, as it is unlikely that the most vulnerable could purchase the products at full cost, especially once overheads and marketing costs are built into the price. The base price of Sprinkles® (depending on manufacturer) is about US$0.03 per sachet, and the price for Nutributter® is about US$0.08 per sachet. With overheads built in, the price is likely to double. Furthermore, if it is determined that children should take two sachets a day to maximize the amount of iron a child can consume in a day, without delivering more iron than fortified complementary foods, the cost could be even more.
Another concern is whether the use of MNP or LNS products containing lower doses of iron would be efficacious if only purchased a few times a week. In Bangladesh, a flexible administration of Sprinkles® led to better adherence and higher anaemia cure rates compared with daily administration (Ip et al. 2009). In a market-based system in Kenya, purchasing and consuming Sprinkles® about once per week was related to anaemia reductions in children (Suchdev et al. 2009). However, in both of these studies, the MNP used contained 12 mg of iron vs. the 6 mg used in this formative work. It is not certain that the efficacy of flexible administration would be replicated if lower-dose iron content MNP and LNS are used. Currently, there are several ongoing studies looking at the efficacy of lower doses of iron in products such as MNP. Depending on the results from these studies and the ongoing systematic review of the association between iron intake and mortality in malaria-endemic areas, recommendations for future programs using MNP and LNS could change substantially. Additionally, it should be noted that while this study explored two potential home fortification products, there are a variety of other fortification products available that were not included in this assessment. The selection of these products was purposeful but should not imply that these products are superior to others available, or that they are the most appropriate for this setting.

Despite concerns that many families would not be able to afford these products, even at a very low cost, our interviews and home visits show that most families are already used to buying special foods for their young children, such as yogurt, eggs, bean fritters, oranges and candies. While Sprinkles® is a powder that must be added to other food, Nutributter® is a sweet peanut-based spread that can either be mixed into food or that children can eat separately and could be similarly categorized as some of the sweet items already being purchased for children. It is not clear if Nutributter® was available for purchase, whether it would be bought in addition to or instead of these special foods, or which special foods the Nutributter® might displace. Further work is needed to address these issues adequately. The considerable concern for children’s nutritional status and corresponding health, combined with the fact that families already regularly buy special foods for young children, suggests that it is likely that many families would be willing to purchase Sprinkles® or Nutributter® for their children if the products were available in the community. However, although the results from this formative work suggest that families would be willing to pay for these products on a frequent basis, there is no certainty as to what extent willingness to pay will translate into actual purchasing behaviour. Research is limited in this area in relation to nutritional products, but there have been several studies that have looked at hypothetical and actual willingness to pay for health-related products such as insecticide-treated bednets (ITNs) (Onwujekwe et al. 2001). The results from Onwujekwe’s study in Nigeria found that 76% of people that were hypothetically willing to pay for ITNs actually purchased them. Factors such as the number of people living in the household, sex and annual expenditure on gifts affected people’s actual willingness to pay. Prior exposure to free ITNs was negatively associated with actual willingness to pay. Further work would be necessary in Niger to determine actual purchasing behaviour and to be able to determine the optimal price to charge for the products or the level of subsidy to include.

Other studies in Niger on people’s willingness to pay for health-related products, such as condoms and water purification, have found that a major barrier, affecting not only the price but the availability of the products, is the lack of a well-developed system for delivering products. Since 2003, the German Development Corporation (GTZ) has been promoting the use of condoms through Animas-Sutura using a social marketing approach. While they have found that people are willing to purchase condoms at around US$0.05 per condom, a major barrier has been distribution (German Development Corporation 2009). This problem has also been encountered by Société de Transformation Alimentaire®, who has been producing and selling a micronutrient-fortified cocoa and milk-based product called GrandiBien® since 2007 (Fernandez et al. 2009). GrandiBien® has been successfully marketed and distributed in Niamey, and

Formative research has demonstrated that mothers value the product and are aware of its beneficial effects on children and regularly purchase it. However, scaling up the approach to more rural areas of the country has been challenging. Even if the distribution system is made as efficient as possible, the population is scattered over a very large territory and costs will be higher than in more populous and urbanized settings. The results from this analysis suggest that in addition to transporting the products into rural areas, other factors such as product quality (including expiration and protective packaging), credibility of the vendor and protection of the distribution site from environmental conditions may affect willingness to purchase.

Both products were well liked, but mothers generally preferred Nutributter® to Sprinkles®. Although Nutributter® was preferred, many people disliked splitting the sachet, and a single sachet would be advisable in the future. Despite concerns that asking mothers to give the product twice a day would be burdensome or reduce adherence, most mothers had no difficulties giving the products to their children twice a day.

Most people said that they would prefer to buy these products in pharmacies or health centres, as the products will be better protected and are less likely to be expired, and prices will be fixed. The main problem with selling the products in pharmacies is that pharmacies are less common in rural areas. Selling the products in health centres may also be problematic as the health care system in Niger provides free health care for children less than 5 years of age, and mothers would expect products given to their children to be free. If these products were to be sold in Niger, it is likely that they would have to be sold from a variety of locations that both ensured the quality of the product as well as the accessibility to remote populations.

Limitations of this analysis include that data were only collected in two main areas of Niger that may not necessarily be representative of other parts of the country, particularly more food-insecure areas. Data were collected, transcribed and analysed in four different languages, and it is possible that some intention or meaning was lost in some places. Additionally, social desirability may have influenced participants’ responses. This analysis also has multiple strengths. We used rigorous methodology including training and piloting to test the interview guides and standardize the research assistants, back translations of guides and multiple reviews of notes. Data were collected in different areas of rural and urban Niger from multiple types of informants, including mothers, fathers and grandmothers. Finally, all of this extensive formative work was done to aid in the development of a programme. Often, programmes do minimal or no formative work to understand the local context.

This study did not assess specific breastfeeding or complementary feeding behaviours during the 4-week home study and is thus unable to determine how these behaviours may have been impacted by the intervention. It is important that any future programme carefully monitor usage of the products, including that children of the appropriate age are using the product and that the product is not interfering with other recommended feeding behaviours. While the intention of this formative work was to develop a market-based distribution system, promotional materials should still include messages and other strategies to support good hygiene practices and recommended infant feeding behaviours, including how these products should be a part of a broader breastfeeding and complementary feeding context.

The findings from this formative work suggest that either Nutributter® or Sprinkles® would be well accepted but that overall, Nutributter® would be the preferred product, even though it is more expensive. To ensure that the most vulnerable populations have access to the products, it may still be advisable to consider using these products on a larger scale, possibly using a mix of distribution mechanisms that may include free, subsidized and/or market-based distribution given that (1) nutritional deficiencies between 6 and 23 months lead to irreversible damage; (2) MNP and LNS can effectively address some of these deficiencies; and (3) these products are acceptable. Further work is needed to determine what distribution system(s) could be used, especially in the more rural and inaccessible areas of the country. Working with other social marketing programmes already established in Niger could provide an excellent opportunity to market nutritional products such as...
these alongside other health-related products. Any system promoting the use of products such as Sprinkles® or Nutributter® should be integrated into a comprehensive infant and young child nutrition strategy to ensure that breastfeeding and other complementary feeding interventions are supported.

Acknowledgements

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Special thanks to Mamane Zeilani and Virginie Claeyssens of Nutriset and Vikram Kelkar of Hexagon for working with us to procure the Nutributter® and Sprinkles® for this project. We are grateful to the logistics coordinator, interviewers, typist and drivers for all of their hard work, and to the families who participated in this project.

Conflicts of interest

The authors have no financial relationships or conflicts of interest to disclose.

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to pay for insecticide-treated nets in five Nigerian communities. *Tropical Medicine & International Health* 6, 545–553.


Implementation of a programme to market a complementary food supplement (Ying Yang Bao) and impacts on anaemia and feeding practices in Shanxi, China

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Abstract

In China, a full fat soy powder mixed with multiple micronutrient powders (Ying Yang Bao (YYB)) was developed, and the efficacy of YYB was shown in controlling anaemia and improving child growth and development. However, prior to 2008, there was no sustainable way to provide YYB to vulnerable populations, except through free distribution by the government. This study was to test the concept of public-private partnership (PPP) to deliver YYB and to evaluate the effectiveness of marketing YYB through PPP. Programme activities included development of a complementary food supplement (CFS) national standard, product concept test, product development and marketing, behavior change communication, monitoring and evaluation. Baseline and end-line surveys were used to evaluate product awareness, purchasing and the impacts of the project on anaemia and feeding practices. A Chinese CFS standard was approved. Caregivers and their 6- to 24-month-old children participated in the baseline (n = 226) and the end-line survey (n = 221). A concept test at the baseline survey showed that 78% of caregivers were willing to buy YYB at 0.1 USD. After developing the product and implementing the intervention for 8 months, 59.6% of surveyed caregivers purchased YYB. While not significant, the prevalence of anaemia was marginally lower at the end line (28.8%) than at the baseline (36.2%). For those purchasing YYB, the risk of anaemia was significantly reduced by 87% of odds (P < 0.009). The end-line survey found that feeding practices had improved significantly following the intervention. An enabling policy and regulatory environment in which CFSs are defined and parameters for appropriate marketing are identified as a prerequisite for marketing YYB or other nutritious CFS. Public and private advocacy and marketing could successfully increase awareness of YYB and access and use through market channels. The YYB project may be effective for reducing anaemia and improving feeding practices.

Keywords: marketing, infant food, fortified food, Ying Yang Bao, anaemia, feeding practice.

Introduction

Multi-nutrient powders (MNPs) have been used in numerous studies and now in large-scale programmes for over 10 years. Their efficacy and effectiveness in reducing iron deficiency have now been well documented in many countries (Zlotkin et al. 2003a,b; Christofides et al. 2006; Giovannini et al. 2006; Hyder et al. 2007; Menon et al. 2007). These MNP products include no protein or essential fatty acids, and are to be mixed into the child’s traditional complementary food from 6 to 24 months of age. While they have
been shown to improve micronutrient status and motor development, micronutrient powders alone have not had an impact on child growth (Adu-Afarwuah et al. 2007, 2008). However, a study in India showed that when combined with existing supplemental nutrition programmes, enhanced monitoring and programme delivery, micronutrient powders had significant positive impacts on children’s growth (Avula et al. 2011).

In China, Ying Yang Bao (YYB), an MNP, was developed that also included essential fatty acids and protein through the inclusion of full fat soy flour. In 2001 to 2004, a study was conducted in Gansu, China among children 4–12 months of age testing the effectiveness of this complementary food supplement (CFS) (Wang et al. 2006, 2007). Results showed that use of YYB reduced anaemia prevalence by 45% in 6 months (Wang et al. 2009). Child growth (weight and length) improved over the placebo group that received an isocaloric unfortified rice flour (Wang et al. 2007). A follow-up study found that those given YYB had significantly higher IQs than controls, and this difference was sustained until age 6 years [IQ score 3.1–4.5 points higher (Chen et al. 2010)]. This product contained whole soybean flour fortified with iron, zinc, calcium, B2, and D, and was designed to be added to home-made complementary foods.

While acceptance of the product was high when given free by health workers to families, sustainability of government programmes that provide nutritious products to the population is a challenge when resources are constrained. Since even poor families spend funds on snack foods for young children in rural China, finding ways to market products to poor families can potentially improve children’s nutritional status and development in a sustainable way.

The previously tested product was reformulated and fortified with more micronutrients (iron, zinc, calcium, Vitamin A, D, B1, B2, B12 and folic acid) compared to the previous formulation (iron, zinc, calcium, vitamin B2 and vitamin D) (Table 1). The

### Table 1. Formulation of Ying Yang Bao used in this project

<table>
<thead>
<tr>
<th>Average level per sachet (12 g)</th>
<th>WHO RNIs or AI (%)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>6–12 months</td>
</tr>
<tr>
<td>Protein</td>
<td>3 g</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>49</td>
</tr>
<tr>
<td>Omega-3 fatty acids (mg)</td>
<td>131</td>
</tr>
<tr>
<td>Omega-6 fatty acids (g)</td>
<td>1.0</td>
</tr>
<tr>
<td>Calcium</td>
<td>250 mg</td>
</tr>
<tr>
<td>Iron (2.5 mg from EDTA iron and 2.5 mg from ferrous fumarate)</td>
<td>5 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>5 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0.3 µg</td>
</tr>
<tr>
<td>Folic acid</td>
<td>50 µg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>250 µg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>200 IU</td>
</tr>
</tbody>
</table>

AI, adequate intake; EDTA, ethylenediamine tetraacetic acid; RNIs, recommended nutrient intakes; WHO, World Health Organization.

### Key messages

- An enabling policy and regulatory environment is a prerequisite to sustain a market-based CFS project.
- Public and private advocacy and social marketing could successfully increase awareness of YYB.
- Market-based YYB projects can be effective for anaemia control and improving infant and young child feeding practices.

generic name Ying Yang Bao (meaning ‘nutrient sachet’) was used to describe and register the product. YYB is a fortified product, with nutrient levels meeting the World Health Organization (WHO) RNIs (recommended nutrient intakes) for several nutrients as shown in Table 1. The nutrients used here were based on Chinese dietary patterns and nutrients likely to be missing in the children’s diets.

This paper describes a project to test the use of public–private partnerships (PPPs) to market this CFS in rural China to low-income families of children 6–24 months of age.

**Programme activities**

In this project the Food Fortification Office (FFO) of the Chinese Center for Disease Control (China CDC), the Capital Institute of Pediatrics (CIP) and QingDao Biomate Foodstuff Company (Biomate) worked collaboratively to market YYB through a PPP with a grant from Global Alliance for Improved Nutrition (GAIN). The China CDC was responsible for overall project management, study design, product formulation improvement and social marketing. The CIP conducted both baseline and end-line surveys and behaviour change communication in both breastfeeding and complementary feeding with introduction of YYB for the target population. Biomate, a company producing primarily fortified noodle products with a wide distribution network throughout the country, produced and distributed the product called Yu er Bao, meaning ‘Nurture your child sachet’ and conducted marketing activities. The product was marketed through Biomate’s sales chain with advocacy and social marketing support from local health care providers in the maternal and child health care system. Maternal and child health care centres focused on education and publicity about the use of YYB in order to increase its coverage and compliance.

The project took place in Huguan county and Changzhi county, located in Shan’xi province, in the north of China. Shan’xi province has a population of over 34 000 000, and each county contains about 300 000 people. The project counties are in relatively underdeveloped regions with a large number of children suffering from growth retardation and anaemia. The number of children 6–24 months of age in the target area is about 6000. Residents in these two counties, though poor, are financially able to afford CFSs for infants and young children.

**Project timeline**

This project was initially designed to be implemented over a 20-month period from May 2008 to January 2010. The product was revised and the social marketing plans were developed beginning in May, 2008. However, the actual marketing activities and advocacy of YYB were implemented later than planned, during the period of May 2009 to December 2009, due to time needed for the official registration of the product in order for it to be marketed. From April 2008 through February 2009, Biomate worked on developing the product, taste testing it, and revising its formulation to make it low cost, yet acceptable. Also during this time, China CDC and CIP developed social marketing materials and worked with health centres to train staff on the importance of continued breastfeeding and use of YYB to improve child nutrition. Once the product was registered, the project intervention began, thus the intervention lasted only 8 months.

In March 2008, a baseline survey among a sample of caregivers of children 6–24 months of age was conducted. This baseline included a concept test of the views about purchase of YYB, as well as questions about knowledge, attitudes and practices related to infant feeding and childhood anaemia. The follow-up study was conducted in January 2010 to assess the impacts of the project.

**Development of CFS standard**

While YYB could be freely distributed in emergencies (e.g. Sichuan earthquake-affected regions) or provided free of cost through maternal and health programmes in China, in order for the product to be sold, it first needed to be registered with the government. However, prior to 2008, there was no category for a CFS, so therefore registration was not possible. The Chinese Ministry of Health (MOH) began work...
with the National Standardization Administration to develop and get approval for a CFS standard (shown in Box 1) in 2008. The National Standard for Complementary Food Supplements (GB/T22570-2008) was approved by the MOH and the Standardization Administration of the People’s Republic of China on 15 December 2008 with an effective date from 1 March 2009.

**Box 1. Sections of Chinese standard for fortified complementary food supplements**

<table>
<thead>
<tr>
<th>Classification number 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICS 67.040</td>
</tr>
</tbody>
</table>

GB/T22570-2008

**General Standard for Complementary Food Supplements**

Issued on 2008-12-15  Implement from 2009-03-01

Ministry of Health of the People’s Republic of China
Standardization Administration of the People’s Republic of China

1 **Scope**

The Standard prescribes terminology and definition, basic principle, technical requirements, packaging, labeling, storage, and analytical methods of complementary food supplements.

The Standard is applicable for nutrient supplements added to complementary foods for 6–36 month-old infants.

2 **Normative references**

The following document contains provisions which, through reference in this text, constitute provisions of the Standard. As references with labeled dates, subsequent amendments (excluding error amendments in the text) to, or revisions of any of the publications are not applicable to this standard. However, the parties who achieve an agreement according to this standard are encouraged to research whether the latest editions are applicable. As for undated references, their latest edition of the normative document is applicable to this standard.

- GB/T 601 Preparation for chemical reagents and standard titration solution
- GB 2760 Hygienic Standards for Uses of Food Additives
- GB/T4789.2 Determining total count of bacteria colony, food microbiology and hygiene examination
- GB/T4789.3 Determining total count of *Escherichia coli*, food microbiology and hygiene examination
- GB/T4789.4 Determining total count of salmonella, food microbiology and hygiene examination
- GB/T 5009.5 Analyzing protein content in foods
- GB/T5009.11 Analyzing total arsenic and inorganic arsenic in foods
- GB/T5009.12 Analyzing lead in foods
- GB/T5009.24 Analyzing Aflatoxin M1 or B1 in foods
- GB/T5009.93 Analyzing selenium in foods
- GB/T5413.9 Analyzing Vitamin A, D, E, infant formula and milk powder
- GB/T5413.10 Analyzing Vitamin K1, infant formula and milk powder
- GB/T5413.11 Analyzing Vitamin B1, infant formula and milk powder
- GB/T5413.12 Analyzing Vitamin B2, infant formula and milk powder
- GB/T5413.13 Analyzing Vitamin B6, infant formula and milk powder
- GB/T5413.14 Analyzing Vitamin B12, infant formula and milk powder
- GB/T5413.15 Analyzing niacin and niacinamide, infant formula and milk powder
- GB/T5413.16 Analyzing folic acid (activity of its salt), infant formula and milk powder
- GB/T5413.17 Analyzing pantothenic acid, infant formula and milk powder
- GB/T5413.18 Analyzing Vitamin C, infant formula and milk powder
- GB/T5413.19 Analyzing free biotin, infant formula and milk powder
- GB/T5413.20 Analyzing choline, infant formula and milk powder
- GB/T5413.21 Analyzing calcium, iron, zinc, sodium, potassium, magnesium and manganese, infant formula and milk powder
- GB/T6682 Specification and testing method for water used in analytical laboratory
- GB 7718 General Standard for the Labeling of Prepackaged Foods
- GB13432 General Standard for the labeling of prepackaged foods used for special diet
- GB 14880 Hygienic standard for the use of nutritional fortificants in food

Box 1. Continued

GB 14881 General hygienic standard for food industry
JJF 1070 Rules of Metrological Inspection for Net Quantity of Prepackaged Products with Fixed Content
Chinese Dietary Recommendation Intakes (Chinese Nutrition Society, 2000)

3 Terminology and definitions
The following terminology and definition are applicable to this Standard.

3.1 Complementary foods
Complementary foods are the foods (home-made or industrialized) that are introduced to infants and young children to meet their nutrient requirement after 6 months of age along with breastfeeding.

3.2 Complementary food supplements
Complementary food supplements are the multiple, high-dense micronutrients (vitamin and minerals) supplements that are added to complementary foods for 6–36 months infants and young children, which may contain or not contain food base or other fillers. The common complementary food supplements include: food-based nutrient supplements, Foodlets and Sprinkles®.

3.2.1 Food-based nutrient supplements
Food-based nutrient supplements are the food base fortified with multiple high-dense vitamin and minerals, which could be powder, particle, or semi-solid and provide some high quality protein and small amount of energy.

3.2.2 Foodlets
Foodlets are crushable or dispersible tablets made with small amount of milk powder (or soybean powder) fortified with multiple high-dense micronutrients, which could be added into complementary foods after crushing or dispersing.

3.2.3 Sprinkles®
Sprinkles® are complementary food supplements containing multiple high-dense micronutrients without food base in powder or/and particle form that are packaged in sachets.

4 General principles
4.1 Complementary food supplements are applicable to infants and young children aged 6 to 36 months.

4.2 Guidelines for adding nutrients in complementary food supplements.
4.2.1 Daily rations for vitamin and minerals intakes from complementary food supplements are determined based on RNIs, AIs and ULs for 0.5–1 year and 1–3 year infants and young children respectively (Table 1). The reference values of RNIs, AIs and ULs are from Chinese Dietary Recommended Intakes.

Table 1. Daily rations for vitamin and minerals intakes from complementary food supplements

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Name of nutrient</th>
<th>Minimal amount</th>
<th>Maximum amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat-soluble vitamins</td>
<td>Vitamin A, D, D, and K</td>
<td>30% RNIs (AIs)</td>
<td>90% RNIs (AIs)</td>
</tr>
<tr>
<td>Water-soluble vitamins</td>
<td>Vitamin B1, B2, B6, B12, pantothenic acid, choline,</td>
<td>40% RNIs (AIs)</td>
<td>50% ULs</td>
</tr>
<tr>
<td></td>
<td>biotin, and vitamin C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Folic acid and niacin</td>
<td>40% RNIs (AIs)</td>
<td>100% RNIs (1–3 year)</td>
</tr>
<tr>
<td>Macro-elements</td>
<td>Calcium and magnesium</td>
<td>30% RNIs (AIs)</td>
<td>60% RNIs (AIs)</td>
</tr>
<tr>
<td>Trace elements</td>
<td>Iron and zinc</td>
<td>30% RNIs (AIs)</td>
<td>90% RNIs (AIs)</td>
</tr>
<tr>
<td></td>
<td>Selenium and copper</td>
<td>30% RNIs (AIs)</td>
<td>60% RNIs (AIs)</td>
</tr>
</tbody>
</table>

4.2.2 Vitamin A, D, B1, B2, iron, and zinc are required for these products, and the other nutrients are optional. For food-based nutrient supplements, protein and calcium are also required and protein should come from dairy, bean or others.

4.3 Recommended daily ration of complementary food supplements: food-based nutrient supplements: 10–20 gram; Foodlets: 1.5–3 gram; and Sprinkles®: 0.8–2 gram.

4.4 Workshops that produce complementary food supplements should at least meet class 300,000 clean requirements.

4.5 Use of complementary food supplement is adding it into complementary foods directly.

5 Technical requirements
5.1 Requirements for materials
5.1.1 Vitamins and minerals
All raw materials of vitamin and minerals are listed in Annex A of this Standard. Their quality shall conform to the current national standard of food additives or Chinese pharmacopoeia. If there is no current national standard, the current industrial standard should be met.

5.1.2 Food base
Food bases are directly edible cow milk (or goat milk) and its products, soybeans and their products that are appropriate for direct use by infants and young children to provide high quality protein and small amount of energy; their quality shall conform to the current relevant national standard or industrial standard. Soybeans and their products should be processed with high temperature techniques to get rid of anti-nutrient factors such as pancreatic protease inhibitor.
Box 1. Continued

5.1.3 Auxiliary materials
Auxiliary materials are those edible, non-food additives materials with filling or sticky functions, which are added to meet the requirements of producing techniques. Their quality shall conform to the current relevant national standard or industrial standard.

5.1.4 Food additives
Food additives shall conform to the provisions stipulated in GB 2760. Their quality shall conform to the current relevant national standard or industrial standard.

5.2 Organoleptic characteristics
Organoleptic characteristics shall follow Table 2’s stipulation.

Table 2. Organoleptic characteristics

<table>
<thead>
<tr>
<th>Name</th>
<th>Organoleptic characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food-based nutrient supplements</td>
<td>Characterized with own special flavor, taste and color; powder, in particle or semisolid form; must not contain foreign matters or bad smell</td>
</tr>
<tr>
<td>Foodlets</td>
<td>Tablet-shaped, easily crushable or dispersible in water or milk; must not contain foreign matters or bad smell</td>
</tr>
<tr>
<td>SpinkleS®</td>
<td>In powder or particle form; must not contain foreign matters or bad smell</td>
</tr>
</tbody>
</table>

5.3 Physical and chemical requirements
5.3.1 Net content
The net content should follow the stipulation of JJF 1070

5.3.2 Nutrient content
Nutrient content (daily ration) should follow Table 3’s stipulation in complementary food supplements.

Table 3. Nutrient daily ration in complementary food supplements

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Daily ration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6–12 months</td>
<td>13–36 months</td>
</tr>
<tr>
<td>Protein (g) &gt;</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>120–240</td>
<td>180–360</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>3–9</td>
<td>3.6–10.8</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>2.4–7.2</td>
<td>2.7–8.1</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>0.18–0.36</td>
<td>0.24–0.48</td>
</tr>
<tr>
<td>Selenium (ug)</td>
<td>6–12</td>
<td>6–12</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>0.12–0.36</td>
<td>0.24–0.48</td>
</tr>
<tr>
<td>Vitamin A (ug)</td>
<td>120–360</td>
<td>150–450</td>
</tr>
<tr>
<td>Vitamin D (ug)</td>
<td>3–9</td>
<td>3–9</td>
</tr>
<tr>
<td>Vitamin E (mg)</td>
<td>0.9–2.7</td>
<td>1.2–3.6</td>
</tr>
<tr>
<td>Vitamin K (ug)</td>
<td>0.12</td>
<td>0.24</td>
</tr>
<tr>
<td>Vitamin B1 (mg) &gt;</td>
<td>0.2</td>
<td>0.24</td>
</tr>
<tr>
<td>Vitamin B2 (mg) &gt;</td>
<td>1.2–10</td>
<td>2.4–10</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>0.12</td>
<td>0.2</td>
</tr>
<tr>
<td>Vitamin B6 (mg) &gt;</td>
<td>32–150</td>
<td>60–300</td>
</tr>
<tr>
<td>Folic acid (ug) &gt;</td>
<td>0.2</td>
<td>0.36</td>
</tr>
<tr>
<td>Vitamin B12 (ug) &gt;</td>
<td>0.72</td>
<td>0.8</td>
</tr>
<tr>
<td>Pantothenic acid (mg) &gt;</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Choline (mg) &gt;</td>
<td>2.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Biotin (ug) &gt;</td>
<td>20</td>
<td>24</td>
</tr>
</tbody>
</table>

5.4 Hygienic requirements
Complementary food supplements should conform to the hygienic requirements listed in Table 4.

6. Package
### Box 1. Continued

#### Table 4. Hygienic indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Cutoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (mg/kg)</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Arsenic (mg/kg)</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Aflatoxin M1 or B1 (ug/kg)¹</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Activity of urease (U/g)²</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Total count of bacteria (cfu/g)</td>
<td>&lt; 10000</td>
</tr>
<tr>
<td>Total count of <em>Escherichia coli</em> (cfu/g)</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Total count of salmonella (cfu/25 g)</td>
<td>&lt; 0</td>
</tr>
</tbody>
</table>

¹Aflatoxin M1 is tested only in dairy products; Aflatoxin B1 is tested only in products containing cereal, nuts or beans.

²Urease is tested only in products containing soybeans.

Shaped packaging containers and materials should meet the relevant national food hygiene standards.

#### 7. Labeling

7.1 Labeling should meet the requirements of GB 7718 and GB13432.

7.2 Product should be labeled with ‘complementary food supplements’ right below the name of the product.

7.3 All ingredients and their compositions should be labeled.

7.4 Nutrient compositions must be labeled. Daily ration of energy, protein, fat, carbohydrate and micronutrient of the product should be listed and the percentage of micronutrient daily ration relative to 0.5–1 year or 1–3 year RNIs (or AIs) should be given too. For those products applicable for 6–36 month infants and young children, the percentages of micronutrient daily ration relative to both 0.5–1 year and 1–3 year RNIs (or AIs) must be labeled.

7.5 ‘Dosage and administration’ should also be labeled.

7.6 Cautions and ‘The product should not replace breast milk and complementary foods for infants and young children. The product should not be given together with formulized foods or nutrient supplements for infants and young children.’ must be labeled.

#### 8. Storage and transportation

8.1 Products shall be kept in a cool, dry, and well-ventilated place and kept away from toxic, poisonous, smelly, volatile, erosive substances.

8.2 Avoid direct sunlight, rain and do not mix the products with toxic, poisonous, smelly substances that affect product quality during shipment.

#### 9. Analytical methods

Annex A: List of vitamins and minerals

Annex B: Analytical method for activity of urease

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In addition to product registration, all processed food producers need to be certified by the General Administration of Quality Supervision, Inspection and Quarantine for food production permission. All processed food should be inspected and meet its requirements before entering the market. All qualified products should be labelled with the QS (Quality Safety) logo. Without the QS certificate, a product cannot be legally sold through normal distribution channels. However, for this project, a special research exception was allowed.

As a new food category, CFSs were not included in the current QS list. Therefore, the producers could not be certified specifically for production of YYB in a short time period. Both China CDC and producers are working together to add YYB to the list and to get it certified for future sales.

#### Product development

The first product developed with Biomate contained full fat soybean powder in granular form, which had a coarse feel in the mouth. Biomate revised the product after taste tests showed 8% of caregivers of 160 children aged 6 months to 5 years found the product unacceptable (Fig. 1). Soy isolate and soy milk powder were used to improve the taste and mouth feel, the granular form was replaced with powder form to avoid the coarse feel in the mouth, and peanut and sesame were added to conceal the soy flavor. This adaptation led to only 2% who found it unacceptable.
The changes made in the product led to an increase in price, from the originally estimated $0.10 (0.7 RMB) to $0.15 (1 RMB) per daily sachet. The cost to the company was $0.10 per sachet; thus, the margin for retailers or village doctors was only about $0.05 per sachet. This price of $0.15 covered the cost of producing and distributing the product, but did not cover the social marketing conducted by the MOH which was paid for by the grant funds from GAIN.

Demand creation for YYB

Two lines of demand creation were used in this PPP. The government conducted behaviour change communication for health workers and the public, and Biomate conducted marketing activities to the public through retail outlets. Messages about optimal breastfeeding practices were incorporated in behaviour change communications.

Behaviour change communication by the health system

Based on the results of the concept test, behaviour change communication activities were developed by China CDC and CIP. Communications were targeted to health workers and family members. Materials included handbooks about infant and young child feeding for parents, booklets about YYB for health workers and television spots for the public.

About 4470 copies of a Handbook for Infant Feeding in Huguan County and 2000 copies in Changzhi County respectively were distributed to caregivers by maternal and child health care physicians or village doctors. Each caregiver received one copy of the handbook and the health worker explained the contents of the handbook and answered the related questions. This number is similar to the number of target population children 6–24 months of age in each county, respectively, or a total of 6000 children 6–24 months of age.

In March, 2009 in Changzhi County and in September 2009 in Huguan, the MCH (Maternal and Child Health) centres sponsored television programmes on YYB which were aired on local TV stations. Articles introducing the project background, objectives, target population, sales locations and price of YYB, as well as instructions on how to prepare YYB, were published in a local newspaper in Huguan county.

The staff of the maternal and child hospital in each county regularly trains village doctors on how to train caregivers in infant and young child feeding. The use of YYB was incorporated into this health worker training at the township and village level. Caregivers were educated about infant and young child feeding (including use of YYB) during their children’s regular village doctor visits. Brochures were also distributed by paediatricians to families with infants and young children during sick and well child visits at maternal and child health care hospitals.

Marketing by the company

Biomate built up distribution and sales channels by setting up a two-tiered distribution network from county distributors to retailers. Two distributors and 12 retailers were selected for the network. The product was sold and promoted in grocery stores. Biomate organised promotions for YYB, which included hanging banners and distributing brochures. As they did with retailers, the distributors encouraged village doctors to sell YYB in their village clinics and provided commissions. Over the 8-month period of the project, 38 000 sachets were sold at $0.15 to primarily low-to middle-income families.

Evaluation design

Baseline and end-line surveys were conducted to evaluate the effectiveness of the project on anaemia, breastfeeding and complementary feeding knowledge, and behaviour associated with awareness and purchasing of YYB. The baseline survey was conducted in June 2008, and the end-line survey was conducted in January 2010.

Twenty villages were selected from 4 townships for the baseline survey using a convenience sample near the main cities. Thirteen villages were selected from 5 townships for the end-line survey. All families with infants and young children 6–24 months of age in the study villages were recruited for both surveys.

A structured questionnaire was developed based on the indicators for assessing infant and young child feeding practices (World Health Organization 2008). In addition to demographic characteristics including age, gender, maternal age, maternal education, maternal occupation and household size, feeding practices and feeding knowledge were assessed in both the baseline and end-line surveys. Capillary blood samples were collected and haemoglobin was measured by using B-Hemocue.

In the baseline survey, questions were asked to assess the concept of YYB. A sample of the product was presented to caregivers, and questions were asked about acceptability (See Box 2), intention to purchase and factors influencing decisions to purchase.

Statistical analysis

Data were entered by using Epidata 3.02. Univariate analysis was conducted to check the distribution of continuous variables. A t-test was used for mean comparison for continuous variables (e.g. maternal age). A chi-square test was used for categorical variable comparison (anaemia, feeding knowledge and feeding practice). Logistic regression was used to analyse the potential factors associated with awareness of YYB, purchasing YYB and anaemia after adjusting for potential confounders. Linear regression was used to study the factors associated with sales of YYB. SPSS package (version 15.0) was used for all the data analysis with Type I error of 0.05.

Results

Infants and young children aged 6–24 months \((n = 250)\) participated in the baseline survey, and 221 with complete information were included in the analysis. For the end-line survey, 267 infants and...
young children aged 6–24 months were interviewed and 226 had complete information.

The evaluation included demographic and socio-economic information, haemoglobin, consumption of complementary foods, intake of YYB and compliance as well as the parents’ knowledge on infant feeding.

**Product concept test**

In the baseline survey, after having been shown the product, caregivers were asked about how well they liked the concept of YYB. The scale was from 1 to 10 (10 meaning ‘like it very much’ and 1 meaning ‘did not like it at all’). The mean ranking by respondents for how well they liked the concept of YYB was 8.0. This varied from 7.9 for caregivers of children 6–11 months, 7.6 for those 12–17 months of age and 8.3 for those 18–24 months of age.

Seventy-eight per cent of the respondents stated they would definitely or probably be willing to pay the price of 0.7 yuan/day ($0.10) for one sachet of YYB. This varied from 84% for caregivers of children 6–11 months, 74% for those 12–17 months of age and 81% for those 18–24 months of age. For the 19% who said they were unsure if they would buy, reasons given were that (i) this was a new product, which has not been consumed previously; (ii) they were not familiar with the product; (iii) they were concerned about the potentially adverse effects of the product. Only 3% said they probably or definitely would not buy YYB.

Respondents were asked where they would most like to buy the product, with multiple responses possible. Most (61%) said they would like to purchase it at supermarkets or franchises, 48% in local food stores in their villages, and 21% in food stores in the town or township.

When asked what would influence them to purchase the product, nearly half (47%) of all respondents stated that television commercials would influence them, or family members (also 47%). Thirty-seven per cent said they would be influenced by a doctor or nurse recommending the product, and 21% by authorities (which could include government or Communist party officials). Less than 5% of respondents stated that attractive packaging, or free samples, or special price reductions/discounts, free offer/bonus pack or online or newspaper ads or articles would influence them.

**Intake and compliance of YYB**

In the end-line survey, more than half (59.6%) of caregivers knew about YYB and 13.5% of caregivers ever purchased it. Given the estimate of 6000 children in the target age, this indicates about 800 children reached with the product. Among those who were aware of YYB, 22.6% purchased the product. Among children whose caregivers purchased the product, 55.6% had consumed the product every day; 40.7% had consumed the product every other day; and only 3.7% had consumed the product occasionally. Thus, more than 95% consumed the product at least three times per week. The purchase of YYB was not related to the child’s age.

While instructions were for YYB to be mixed with the child’s food, surprisingly 61.9% of caregivers prepared YYB with boiled water, and the rest (38.1%) mixed YYB with porridge, noodle soup or other type of food for their children. Powdered soy milk is mixed with water as a common beverage in China, and this may be why many caregivers fed YYB this way to their children, in spite of recommendations to mix it with complementary foods.

**Demographic characteristics of subjects and anaemia**

There were no significant differences between baseline and end-line survey subjects in gender, maternal education level, maternal occupation, household size and maternal age (Table 2). However, children in the end-line survey were significantly younger than those in the baseline survey \( (P = 0.002) \). In the follow-on survey, 81% of caregivers were mothers. Mothers had threefold greater odds of YYB awareness than other caregivers (mainly grandparents).

The prevalence of anaemia among all children was marginally lower in the end line (28.8%) than in the baseline (36.2%) \( (P = 0.098) \). Age, gender and caregivers were not significantly different for anaemic infants between the baseline and end-line survey, but
Maternal education level was significantly higher in the end-line survey than baseline (Table 3). Purchasing YYB was associated with 87% less odds of anaemia than not purchasing YYB at the end line after controlling for the potential confounders (age, maternal occupation, bottle usage, iron-rich food, etc.; \(P = 0.009\)) (Table 4). Use of bottles for infant feeding was also significantly related to lower risk of anaemia.

There was no association between awareness of YYB and anaemia.

Using sales data provided by the manufacturer, the amount of YYB sold by retailers was negatively related to the distance from wholesale to retail store (\(r = 0.35, n = 35, P = 0.038\)).

**Feeding practices**

Because the behaviour change communication activities promoted optimal child feeding in addition to use of YYB, we compared feeding practices at baseline and end line. After controlling for potential confounders (maternal education level and age of child), early initiation of breastfeeding rate, the prevalence of meeting minimal dietary diversity (≥4 food

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**Table 2.** Comparison of maternal and child demographic characteristics between baseline and end line

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline (n = 221)</th>
<th>End line (n = 226)</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (month)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6–8 months (%)</td>
<td>6.3 (14)</td>
<td>16.8 (38)</td>
<td>0.002</td>
</tr>
<tr>
<td>9–11 months (%)</td>
<td>15.8 (35)</td>
<td>15.5 (35)</td>
<td></td>
</tr>
<tr>
<td>12–24 months (%)</td>
<td>77.8 (172)</td>
<td>67.7 (153)</td>
<td></td>
</tr>
<tr>
<td>Gender (% of male)</td>
<td>57.9 (115/199)</td>
<td>55.4 (124/225)</td>
<td>0.579</td>
</tr>
<tr>
<td>Maternal age (y)</td>
<td>27.7 ± 3.4 (135)</td>
<td>27.9 ± 3.6 (217)</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤Junior high school (%)</td>
<td>91.5 (194)</td>
<td>86.4 (189)</td>
<td>0.067</td>
</tr>
<tr>
<td>&gt;Junior high school (%)</td>
<td>8.5 (18)</td>
<td>13.6 (31)</td>
<td></td>
</tr>
<tr>
<td>Maternal occupation</td>
<td></td>
<td></td>
<td>0.533</td>
</tr>
<tr>
<td>Farmer (%)</td>
<td>92.5 (198)</td>
<td>91.9 (199)</td>
<td></td>
</tr>
<tr>
<td>Non-farmer (%)</td>
<td>7.5 (16)</td>
<td>8.1 (20)</td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>4.8 ± 1.0 (219)</td>
<td>4.7 ± 1.1 (222)</td>
<td>0.546</td>
</tr>
<tr>
<td>Caregiver</td>
<td></td>
<td></td>
<td>0.368</td>
</tr>
<tr>
<td>Mother (%)</td>
<td>84.9 (185)</td>
<td>81.4 (184)</td>
<td></td>
</tr>
<tr>
<td>Not mother (%)</td>
<td>15.1 (33)</td>
<td>18.6 (42)</td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 3.** Demographic characteristics of children who were anaemic in baseline and end-line survey

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline (n = 221)</th>
<th>End line (n = 226)</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (month)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6–8 months (%)</td>
<td>9.1 (7)</td>
<td>21.5 (14)</td>
<td>0.071</td>
</tr>
<tr>
<td>9–11 months (%)</td>
<td>24.7 (19)</td>
<td>21.5 (14)</td>
<td></td>
</tr>
<tr>
<td>12–24 months (%)</td>
<td>66.2 (51)</td>
<td>56.9 (37)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.138</td>
</tr>
<tr>
<td>Male</td>
<td>63.2 (48)</td>
<td>50.8 (33)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>36.8 (28)</td>
<td>49.2 (32)</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
<td>0.010</td>
</tr>
<tr>
<td>≤Junior high school (%)</td>
<td>95.8 (69)</td>
<td>78.5 (51)</td>
<td></td>
</tr>
<tr>
<td>&gt;Junior high school (%)</td>
<td>4.2 (3)</td>
<td>16.9 (11)</td>
<td></td>
</tr>
<tr>
<td>Caregiver</td>
<td></td>
<td></td>
<td>0.162</td>
</tr>
<tr>
<td>Mother</td>
<td>92.1 (70)</td>
<td>84.6 (55)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7.9 (6)</td>
<td>15.4 (10)</td>
<td></td>
</tr>
</tbody>
</table>
groups), the prevalence of meeting a minimal acceptable diet and the prevalence of consuming iron-rich food were significantly greater in the end line than in the baseline (Table 5). The early initiation of breastfeeding rate significantly increased from 8.6% at the baseline to 16.8% at the end line. The prevalence of meeting minimal dietary diversity significantly increased from 58% to 74% for breastfed children and from 28% to 54% for non-breastfed children. The prevalence of meeting a minimal acceptable diet significantly increased from 42% to 74% for breastfed children and from 25% to 45% for non-breastfed children. The prevalence of consuming iron-rich food significantly increased from 19% to 57% (P < 0.05).

The baseline and end line ever breastfed rate, continued breastfeeding rate, age of introduction of solid foods and minimal meal frequency rate (Table 5) were not significantly different.

### Discussion

Marketing YYB through a collaboration among China CDC, CPI and Biomate tested the concept – ‘PPP’ for improving infant and young child nutrition in China. Under the project, a Chinese standard for CFSs was approved and implemented, which is the first standard globally for the new category of complementary foods-CFSs. After implementing the intervention for 8 months, 59.6% of surveyed caregivers were aware of YYB and 13.5% of surveyed caregivers purchased YYB. The overall prevalence of anaemia at the end line, which was negatively associated with purchasing YYB, was marginally lower than the one at the baseline.

An enabling environment for appropriate marketing of CFSs is a prerequisite for a PPP project to promote YYB, especially since YYB is part of a new

### Table 4. Adjusted odds ratio (AOR) for anaemia of infants and young children at the end line

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Prevalence of anaemia (# of anaemia/total #)</th>
<th>P-value</th>
<th>AOR</th>
<th>95% CI for AOR Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle usage</td>
<td>26.6% (17/64)</td>
<td>0.017</td>
<td>0.366</td>
<td>0.161</td>
<td>0.833</td>
</tr>
<tr>
<td>Purchased YYB</td>
<td>15.4% (4/26)</td>
<td>0.009</td>
<td>0.130</td>
<td>0.028</td>
<td>0.601</td>
</tr>
</tbody>
</table>

Controlling for age, maternal age, occupation and iron-rich food (including meat, fish, poultry, liver and iron supplements). Reference group: not use or purchasing, anaemia is defined as haemoglobin <110 g/L. n = 131.

AOR, adjusted odds ratio; YYB, Ying Yang Bao.

### Table 5. Comparison of feeding practice between baseline and end line

<table>
<thead>
<tr>
<th>Feeding practice</th>
<th>Baseline (n = 221)</th>
<th>End line (n = 226)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever breastfed (%)</td>
<td>90.0 (198/220)</td>
<td>89.8 (203/226)</td>
<td>P = 0.951</td>
</tr>
<tr>
<td>Early initiation of breastfeeding (%)</td>
<td>8.6 (19/221)</td>
<td>16.8 (37/220)</td>
<td>P = 0.01</td>
</tr>
<tr>
<td>Continued breastfeeding at 1 year (%)</td>
<td>76 (38/50)</td>
<td>66.7 (32/48)</td>
<td>P = 0.307</td>
</tr>
<tr>
<td>Continued breastfeeding at 2 years (%)</td>
<td>42.3 (30/71)</td>
<td>37.0 (20/54)</td>
<td>P = 0.555</td>
</tr>
<tr>
<td>Introduction of solid, semi-solid or soft foods (%)</td>
<td>92.9 (12/13)</td>
<td>71.1 (27/38)</td>
<td>P = 0.098</td>
</tr>
<tr>
<td>Minimal dietary diversity &gt;4 group breastfed (%)</td>
<td>57.5 (73/127)</td>
<td>74.1 (83/112)</td>
<td>P = 0.007</td>
</tr>
<tr>
<td>Minimal dietary diversity &gt;4 group (%) non-breastfed</td>
<td>27.6 (16/58)</td>
<td>53.9 (41/76)</td>
<td>P = 0.008</td>
</tr>
<tr>
<td>Minimal meal frequency (%) breastfed</td>
<td>53.7 (65/121)</td>
<td>51.0 (52/102)</td>
<td>P = 0.683</td>
</tr>
<tr>
<td>Minimal meal frequency (%) non-breastfed</td>
<td>47.1 (24/51)</td>
<td>53.4 (39/73)</td>
<td>P = 0.485</td>
</tr>
<tr>
<td>Minimal acceptable diet (%) breastfed</td>
<td>42.1 (51/121)</td>
<td>73.5 (75/102)</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>Minimal acceptable diet (%) non-breastfed</td>
<td>25.0 (13/51)</td>
<td>45 (33/73)</td>
<td>P = 0.025</td>
</tr>
<tr>
<td>Iron-rich food (%)</td>
<td>19.2 (38/198)</td>
<td>56.8 (117/206)</td>
<td>P = 0.014</td>
</tr>
</tbody>
</table>

Adjusting those potential confounders of demographic characteristics.
category of products. In this case, the lack of a complementary food standard was a bottleneck for implementing the project, and similarly the lack of a Quality Standard (QS) remains a barrier to scale-up through commercialisation. Without the standard, initiation of selling YYB was delayed for more than 1 year, although fast-track approval for the CFS standard was given based on evidence from the trial area and the needs from the Sichuan earthquake area, which has facilitated production and availability of the product in the market. Besides the standard, a production permit (which is called QS) is also required for production and marketing in China. A special permit was given for producing and marketing within the context of the project. In the long run, a corresponding QS permit for YYB will be required for marketing it freely and responsibly in China. Different nations have various rules for introducing a new category of products. As shown in Indonesia (Soekarjo & Zehner 2011) and Kenya (CJ Jones, personal communication), a new standard for CFs is required for initiating a market-based project. In Bangladesh, government authorities did not allow promotion of Monimix, an MNP, through mass media when the product was first introduced through social marketing, which affected the volume of sales (Mr Mahbubur Rahman, personal communication). Having governmental standards and related regulations in place for appropriate composition and marketing and being able to meet them is a requirement for initiating a PPP project and sustaining access by low-income households through markets.

The combination of mass media (local TV and newspaper), brochures, individual counseling and private sector advertisement was effective in promoting YYB. Within the short time period, about 60% of caregivers were aware of YYB. Mothers were more likely to be aware of YYB than grandparents, which could demonstrate that younger women are more attuned to innovations and new products. A study in Bolivia showed that social marketing was able to increase the awareness of multiple micronutrient supplements from 37% at the baseline survey to 61% at the end-line survey among childbearing age women (Warnick et al. 2004). In a similar market-based MNP study in Kenya, vendors’ awareness of MNP was found to be very low during the first 3 months of implementing MNP distribution (Suchdev et al. 2010). However, 1 year later 98% of mothers had heard about MNP.

Although the concept test showed that about 80% of caregivers were willing to buy YYB, the end-line survey found that only 13% of caregivers who were aware of YYB actually bought YYB. Thus, demand for YYB was much lower than expected. In the Kenya MNP project, 33% of households bought MNP at the follow-up survey (Suchdev et al. 2010). The ‘ever use’ of multiple micronutrient supplements increased from 11% to 25% in the Bolivia social marketing project (Warnick et al. 2004). The retailer price of YYB ($0.15) was much higher than Sprinkles® (US$0.027) in Kenya (Suchdev et al. 2010), partially due to the cost of soy, which might be a factor in the lower percentage of caregivers purchasing YYB than MNPs in other settings.

For this project, the private company (Biomate) took on significant risk, because it was introducing a completely new category of product and needed to create demand for it in a policy environment that did not address the product’s existence. This is a concern, especially for small companies with limited capital. In this project, a GAIN small grant funded the social marketing activities through the maternal and child health care system, which partially alleviated this risk. Village doctors were also motivated to promote YYB during the project period because of encouragement from the programme. While the role the public sector played and the policy steps taken were important factors in enabling the promotion of improved infant and young child feeding, social marketing through the health system remains a sensitive issue in China. Health systems promote breastfeeding and complementary feeding, but there is a reluctance to promote processed foods or a specific brand of product that could give a single company an advantage. Thus, marketing through the health system was initially a more difficult approach organisationally than building demand through social marketing carried out by independent organisations such as SMC (Social Marketing Company) in Bangladesh (Mr Mahbubur Rahman, personal communication) and SWAP (The Safe Water and Aids Project) in Kenya that promoted micronutrient powders and improved feeding
practices outside of the context of public health delivery system (Suchdev et al. 2010). Although the YYB formulation was effective in controlling anaemia and improving growth and development in the China context, a more complete formulation has been recommended by the GAIN in its formulation guidelines for correcting inadequate intake of multiple micronutrients worldwide (Table 6). This formulation should be considered by others undertaking a similar project.

As shown in a free distribution of Sprinkles® programme in Mongolia which was implemented for a longer duration (World Vision Mongolia 2005), the prevalence of anaemia in the end-line survey was lower than at baseline. The short period of intervention might have limited the effectiveness of the YYB project. The prevalence of anaemia in this study at the end line was significantly negatively associated with purchasing YYB, which indicated that the project might have positive impacts on anaemia control, although other potential confounding effects cannot be ruled out. The bottle use of formula, milk or water was also associated with lower risk of anaemia. As shown in a few DHS (Demographic and Health Survey) studies in India and Bangladesh (Mihrshahi et al. 2010; Patel et al. 2010), bottle use was associated with a higher household wealth index, which might partially explain the reason for lower risk of anaemia associated with bottle use. However, reported household income was not associated with the risk of anaemia or bottle use in this study. Formula with high iron content might be associated with lower risk of anaemia (Chantry et al. 2007; Hopkins et al. 2007).

Table 6. GAIN guidelines for MNP-soy formulations

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>GAIN guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>10-15% of energy from protein</td>
</tr>
<tr>
<td>Energy</td>
<td>&lt;100-150 kcal</td>
</tr>
<tr>
<td>Omega-3 fatty acids (mg)</td>
<td>at least 130</td>
</tr>
<tr>
<td>Omega-6 : Omega-3</td>
<td>5:10:1</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>200</td>
</tr>
<tr>
<td>Vitamin D (µg)</td>
<td>2.5-5.0 (100-200 IU)</td>
</tr>
<tr>
<td>Vitamin E (mg)</td>
<td>2.5-5.0 (mg α-TE)</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>≥15 (to improve absorbability of iron)</td>
</tr>
<tr>
<td>Thiamin (vitamin B1) (mg)</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>Riboflavin (vitamin B2) (mg)</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>Niacin (vitamin B3) (mg)</td>
<td>3.0-4.8</td>
</tr>
<tr>
<td>Vitamin B6 (mg)</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>Vitamin B12 (µg)</td>
<td>0.45-0.90</td>
</tr>
<tr>
<td>Folic acid (µg)</td>
<td>75-140</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>2.0 mg NaFeEDTA + 3.8-9.6 other types</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>4.2-8.3</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>0.28-0.34</td>
</tr>
<tr>
<td>Selenium (µg)</td>
<td>8.5-17.0</td>
</tr>
<tr>
<td>Iodine (µg)</td>
<td>45-90</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>7.5-15.0</td>
</tr>
<tr>
<td>Biotin (µg)</td>
<td>4-8</td>
</tr>
<tr>
<td>Pantothenic acid (mg)</td>
<td>1-2</td>
</tr>
</tbody>
</table>

GAIN, Global Alliance for Improved Nutrition; MNP, Multi-nutrient powder.

practices outside of the context of public health delivery system (Suchdev et al. 2010). Although the YYB formulation was effective in controlling anaemia and improving growth and development in the China context, a more complete formulation has been recommended by the GAIN in its formulation guidelines for correcting inadequate intake of multiple micronutrients worldwide (Table 6). This formulation should be considered by others undertaking a similar project.

As shown in a free distribution of Sprinkles® programme in Mongolia which was implemented for a longer duration (World Vision Mongolia 2005), the prevalence of anaemia in the end-line survey was lower than at baseline. The short period of intervention might have limited the effectiveness of the YYB project. The prevalence of anaemia in this study at the end line was significantly negatively associated with purchasing YYB, which indicated that the project might have positive impacts on anaemia control, although other potential confounding effects cannot be ruled out. The bottle use of formula, milk or water was also associated with lower risk of anaemia. As shown in a few DHS (Demographic and Health Survey) studies in India and Bangladesh (Mihrshahi et al. 2010; Patel et al. 2010), bottle use was associated with a higher household wealth index, which might partially explain the reason for lower risk of anaemia associated with bottle use. However, reported household income was not associated with the risk of anaemia or bottle use in this study. Formula with high iron content might be associated with lower risk of anaemia (Chantry et al. 2007; Hopkins et al. 2007).

In conclusion, expanding the use of YYB could be an effective way for controlling anaemia and improving infant and young child feeding practices.
However, an enabling policy and regulatory environment in which CFSs are defined and parameters for appropriate marketing are identified is a prerequisite to initiating a market for YYB or other CFSs. Public and private advocacy and social marketing could successfully increase awareness of YYB, and combining public distribution and market based approaches could have an even greater potential to improve large-scale access by low-income households to CFSs. However, investments in demand creation need more time and effort, especially in order to harmonise marketing with public messaging. In the case of China, despite promising indications of demand and impact, large-scale access by the poor to YYB on a sustained basis will not be possible unless a QS accreditation is established.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Legislation should support optimal breastfeeding practices and access to low-cost, high-quality complementary foods: Indonesia provides a case study

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Abstract

It is important to support women to exclusively breastfeed for 6 months and continue breastfeeding for 24 months and beyond. It is also necessary to provide the poor with access to affordable ways to improve the quality of complementary foods. Currently, many countries do not have the legal and policy environment necessary to support exclusive and continued breastfeeding. Legislative and policy changes are also necessary for introducing complementary food supplements, allowing them to be marketed to those who need them, and ensuring that marketing remains appropriate and in full compliance with the International Code of Marketing of Breastmilk Substitutes. This paper aims to illustrate the above with examples from Indonesia and to identify legislative requirements for supporting breastfeeding and enabling appropriate access to high-quality complementary food supplements for children 6–24 months of age. Requirements include improved information, training, monitoring and enforcement systems for the International Code of Marketing of Breastmilk Substitutes; implementation and monitoring of the Baby-Friendly Hospital Initiative; establishment of a registration category for complementary food supplements to enhance availability of high-quality, low-cost fortified products to help improve young child feeding; clear identification and marketing of these products as complementary food supplements for 6–24-month-olds so as to promote proper use and not interfere with breastfeeding.

Keywords: complementary food supplements, lipid nutrient supplements, micronutrient powders, breastfeeding, Code of Marketing, baby-friendly hospitals, infant and young child nutrition.

Introduction

Exclusive breastfeeding for the first 6 months of life and continued breastfeeding up to 24 months and beyond promotes optimal infant and young child growth and development (World Health Organization & UNICEF 2003). While young infants thrive best when exclusively breastfed, by the time they reach 6 months of age, timely, adequate, safe and properly fed complementary foods need to be introduced in addition to continued breastfeeding in order to fully meet their nutrient needs (World Health Organization & UNICEF 2003). The period around the introduction of complementary foods, unfortunately, is also the time that growth faltering starts to manifest itself (Victora et al. 2010). A balanced diet based on locally available foods including animal products can provide optimal nutrition to the young child. However, large proportions of the population in developing countries cannot afford a balanced diet
Because deficient dietary intake during the so-called ‘window of opportunity’ (the 1000 days between conception and the second birthday) can lead to irreversible impairment of physical and mental growth, development, immunity and future economic potential (Victora et al. 2008), it is important to support women to exclusively breastfeed for 6 months and continue breastfeeding for 24 months and beyond. Additionally, it is also necessary to provide the poor with access to affordable ways to improve the quality of the foods fed to children to complement breast milk after 6 months of age.

Often, the habitual diets of poor children 6–24 months of age in developing countries lack certain micronutrients and essential fatty acids, all essential for growth and development. Rather than replacing the local foods or requiring mothers to cook a different meal for their young children, fortifying the child’s portion of the family meal with these nutrients can be a feasible approach to addressing dietary deficiencies.

Complementary food supplements (CFS) are fortified food-based products to be added to other foods (as ‘point of use’ or ‘home’ fortificants) or eaten alone to improve both macronutrient and micronutrient intake of children 6–24 months of age. Multiple micronutrient powders (MNP) are also used for home fortification, and they can be comprised of micronutrients alone or contain other factors/ingredients, such as essential fatty acids, amylase, and flavouring. Their inclusion as an addition to the traditional foods supports local feeding practices rather than competing with them. Additionally, because of their low water content, they are resistant to spoilage, and the micronutrients in these products cannot interact with each other chemically because there is no water to do so. Studies have documented improved child growth with consumption of the CFS, Nutributter® (Nutriset SAS, Malauay, France), a fortified peanut-based paste (Adu-Afarwuah et al. 2007, 2008) and fortified soy flour (Wang et al. 2007; Chen et al. 2010).

Currently, however, many countries do not have the legal and policy environment to support exclusive and continued breastfeeding. Legislative and policy changes are also necessary for introducing CFS, allowing them to be marketed to those who need them, and at the same time ensuring that marketing remains appropriate and in full compliance with the International Code of Marketing of Breastmilk Substitutes where it applies, and within the spirit of the Code where products are not addressed by the Code. This paper aims to illustrate the above with examples from Indonesia and to identify legislative and policy requirements for supporting breastfeeding and enabling appropriate access to high-quality CFS for children 6–24 months of age.

**Methods**

We reviewed infant and young child feeding (IYCF) practices, legislation, food regulations and national policies related to IYCF in Indonesia. We propose changes to strengthen support for improved IYCF practices.

**Results**

The Republic of Indonesia is the fourth most populous country in the world, with an estimated popula-

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**Key messages**

- Improved information, training, monitoring and enforcement systems for the International Code of Marketing of Breastmilk Substitutes are needed to prevent marketing practices that are harmful to breastfeeding.
- Monitoring of Baby-Friendly hospitals to ensure compliance is essential to improve breastfeeding practices.
- A registration category needs to be established for complementary food supplements to enhance availability of high-quality, low-cost fortified products that do not interfere with breastfeeding and help improve young child feeding.
- Products need to be clearly identified and marketed as complementary food supplements for 6–24-month-olds so as to promote proper use and not interfere with breastfeeding.
An estimated 4.4 million infants are born annually [Statistics Indonesia (Badan Pusat Statistik – BPS) and Macro International 2008]. Although the past decades have seen some major improvements in the health of the Indonesian people (UNICEF 2009), the poorer segments of the population still suffer from lack of access to adequate hygiene, sanitation, food and health care. Twenty-one per cent of the population lives below the international poverty line of less than USD1.25 per person per day, which means that approximately 50 million Indonesians are living in poverty (The World Bank Group 2010). The poorer 60% of the population spends between USD 3.70–11 on food per month per person (World Bank 2010).

Despite declines in recent years, Indonesia still has the highest maternal mortality rate in Southeast Asia, estimated at 228/100 000 live births [Statistics Indonesia (Badan Pusat Statistik – BPS) and Macro International 2008], an infant mortality rate of 31/1000 live births, and an under five mortality rate of 41/1000 (UNICEF 2008). The national prevalence of stunting among children under five is 36.8% (Agency for Health Research and Development. Republic of Indonesia 2008). Among infants 6–11 months, 35% were already stunted, and among young children 12–23 months, this figure increases to 41% (WHO 2009). In addition, micronutrient deficiencies are common, with anaemia prevalence among children under five as high as 50–60% in some areas, while zinc and vitamin A deficiency are also common (Church World Service et al. 2008) (Dijkhuizen et al. 2001). Alarmingly, anaemia is most prevalent among 12- to 23-month-old children, and has been found to be as high as 60–75% (de Pee et al. 2004).

**IYCF practices and the nutrient gap**

Indonesian infants are generally breastfed until well into their second year or beyond, and the median duration of any breastfeeding is 21 months [Statistics Indonesia (Badan Pusat Statistik – BPS) and Macro International 2008]. However, only 32% of infants are exclusively breastfed in the first 6 months of life, as against the goal of 100%. Ironically, breastfeeding practices (early initiation, no prelacteal feeds) are noticeably better among poorer, less educated, rural women whose delivery was not attended by a health professional [Statistics Indonesia (Badan Pusat Statistik – BPS) and Macro International 2008]. Despite the fact that this practice is prohibited by law, distribution of breast milk substitutes within hospitals has been observed (Besar et al. 2004).

The use of infant formula is widespread in Indonesia, even among breastfeeding infants (Fig. 1). Increasing rates of exclusive breastfeeding and discouraging the use of breast milk substitutes would help improve health of Indonesian infants and their mothers.

According to the 2007 Demographic and Health Survey (DHS) [Statistics Indonesia (Badan Pusat Statistik – BPS) and Macro International 2008], half the children at 6–8 months did not consume carotene-rich fruit and vegetables the day and night before the survey, while only about 30% of breastfeeding and 40% of non-breastfeeding infants consumed meat, fish, poultry and eggs. Only 42% of breastfed and 51% of non-breastfed children 6–23 months of age consumed foods made with fat or oil. It can be assumed that if these children’s intake of animal-source foods is also low, they are likely to consume low levels of essential fatty acids, especially if they are not breastfed.

Continued breastfeeding ensures children receive the nutrients in breast milk that they cannot attain in adequate amounts from food (such as calcium and high-quality protein) unless they are fed with other animal and milk products. But of non-breastfed children aged 12-17 months, 24% received no milk products on the preceding day; and at the age of 18–23 months, this increased to 36%. Even though 75% of children aged 6–23 months received animal products on the preceding day, the amount consumed is likely to be small given the high cost and, so, is unlikely to significantly contribute to overall micronutrient intake.

World Health Organization (WHO) and UNICEF recommend the use of complementary products in addition to breast milk after 6 months of age when there is a gap in critical nutrients (World Health Organization & UNICEF 2008). The use of linear programming models for rural and peri-urban Indo-
nesian poor demonstrated that even with adequate intake of breast milk and use of the currently available fortified infant cereals, soy-based foods and animal-source foods in amounts that are affordable to the poor, it is difficult to provide children aged 9–11 months with adequate iron, zinc, calcium and B vitamins because of the cost constraints faced by the average family (Ferguson et al. 2006; Santika et al. 2009). A recent survey in West Timor reported consumption of vitamin A-rich foods to be only 113 RE/day among children aged 12–35 months, while the Recommended Daily Allowance is 400 RE/day (Church World Service et al. 2008). Given the current dietary pattern, there is clearly a need for affordable CFS containing sufficient levels of fortification with the critical micronutrients and essential fatty acids to improve the local diet of infants and young children.

Until recently, the Ministry of Health (MOH) provided, free of charge, fortified blended food to poor children aged 6–11 months and fortified biscuits to poor children aged 12–23 months but has now started distributing a MNP ‘Taburia’ during child health sessions (posyandu) in selected areas instead of these products. The MOH, however, has insufficient funds to distribute MNP to all poor children and, thus, distributes them to selected regions. The product is made locally in East Java and has the potential to be marketed for wider availability. It is registered as a food supplement. A similar product registered in the same category is also being marketed by a subsidiary of a company that also markets infant formula and cereals. As both these products fall in a general category not specifically created for products for older infants and young children, there is no language to ensure that these products are marketed in line with the Code of Marketing of Breastmilk Substitutes or in the spirit of the Code, supporting breastfeeding.

**Policy and regulatory environment with regards to IYCF**

**Breastfeeding**

The Indonesian government gives much attention to IYCF; in particular, to supporting breastfeeding (Minister of Health Republic of Indonesia 2004). A 2009 Health Bill (UU 36/2009) made exclusive breastfeeding until 6 months mandatory and any person ‘intentionally obstructing breastfeeding’ is punishable with imprisonment for up to 1 year and a fine of up to USD
10 000. If a corporation commits this unlawful act, the fine can be tripled. In addition, the business license and/or legal entity status of the corporation can be revoked (Republic of Indonesia 2009).

**Marketing of breast milk substitutes**

Indonesia ratified part of the International Code for the Marketing of Breastmilk Substitutes (the Code) (World Health Organization 1981) in 1997 (Minister of Health, Republic of Indonesia 1997). This decree (which is currently being revised) only addresses infants 0–11 months, thus providing no guidance for marketing of products targeted at young children aged 12 months or older. Furthermore, the language surrounding complementary foods has not lent itself to easy interpretation.

The decree defines breast milk substitutes as ‘food products that are marketed or otherwise meant as infant food and used to substitute breast milk partially or completely’, while complementary foods are defined as ‘food products that are marketed or otherwise stated as foods for infants over 4 months old to meet their nutritional needs in addition to breast milk’. While the definitions are complex, the distinction is critical. Foods marketed or intended as a substitute for breast milk are covered by Code limitations. However, foods marketed as a complement to fulfil the nutrient gaps from 4 months and older are not breast milk substitutes and, thus, may be promoted. Unfortunately, early in the document the text does not clarify the distinction between infant formula and complementary foods, which may add to confusion. Further in the document, there is specific mention of ‘complementary food given using a bottle and nipple’ (and not other complementary foods) as being a ‘commercial breast milk substitute’. While complementary food given using a bottle and a nipple would clearly be covered under the Code, it is not the only manner in which to identify when a complementary food is serving as a breast milk substitute (and as such is subject to the Code). The complexity of defining when a complementary food becomes a breast milk substitute, as well as the language used in the Indonesian decree, might explain some parties’ reluctance to accept complementary foods as an indispensable part of older infants’ and young children’s diets and the need to ethically promote them. The outdated use of 4 months rather than 6 months for age of introduction of solids within the Indonesian Code may have further contributed to a less than whole-hearted universal endorsement of the need to actively encourage the use of high-quality complementary foods and supplements. (This will be changed to 6 months in the forthcoming revised decree.)

As for all food products, a registration permit from the National Agency for Food and Drug Control (BPOM) is required to distribute breast milk substitutes, including imported products. Although quite specific on what exactly is prohibited in terms of marketing of breast milk substitutes, no legal penalties are detailed in the Ministerial Decree of 1997. It only mentions ‘administrative penalties, starting from a verbal reprimand to withdrawal of permits as per the governing laws’. In spite of these existing laws, and certainly in part because of the lack of legal penalties, and difficulties with setting up a monitoring system and systematic enforcement, there are multiple reports of retail level promotion of infant formula, follow-up formula and complementary foods for infants under 6 months, with little or no public sector action to address these Code violations. (Besar et al. 2004).

**Baby-Friendly Hospital policies**

Since the early 1990s, the Indonesian government has made progress in its support of appropriate IYCF practices, including adoption of the Baby-Friendly Hospital Initiative (BFHI) (UNICEF 2009), launched in 1991 by WHO and UNICEF. A maternity facility can be designated ‘baby-friendly’ when it does not accept free or low-cost breast milk substitutes, feeding bottles or teats, and has implemented the Ten Steps Towards Effective Breastfeeding, which include ‘Give newborn infants no food or drink other than breast milk, unless medically indicated’. In 2004, a decree...
from the Minister of Health officially promoted exclusive breastfeeding until 6 months, supported by the Ten Steps Towards Effective Breastfeeding (World Health Organization & UNICEF 1989) together with continued breastfeeding until 2 years along with appropriate complementary feeding (Ministry of Health Republic Indonesia 2004). This was, however, only legislated in October 2009 (Republic of Indonesia 2009).

Despite the fact that legislation supporting breastfeeding references the Ten Steps, it does not require implementation of the BFHI. Reports indicate that implementation of the Baby-Friendly Hospital Initiative has long been neglected, although efforts are being made to revitalize it (Laksono et al. 2010).

There is a need to monitor Baby-Friendly hospitals on an annual basis and require annual recertification so that those not meeting the requirements can be informed and encouraged to make appropriate changes. The DHS illustrates that 70% of infants born in health facilities were given prelacteal feeds, and 57% were not breastfed in the first hour after delivery, illustrating that these facilities were not Baby Friendly. There is also a need to include Baby-Friendly Hospital practices within accreditation criteria for hospitals so that these become an established practice just as standard operational procedures and hospital by-laws are compulsory for hospital accreditation.

In addition to Baby-Friendly policies for hospitals, maternity leave policies and employer policies providing time, space and support for breastfeeding are also critical for exclusive and continued breastfeeding. However, these are beyond the scope of this paper, which is focused on policies directly relating to availability, marketing, use and misuse of infant food products.

National Codex

The Indonesian National Standard for Complementary Foods (SNI MP-ASI) (Head of the National Bureau of Standards 2005) consists of four parts: instant cereal powders, biscuits, ready-to-cook products and ready-to-eat products. The standard defines complementary foods as ‘nutritious foods given in addition to breastmilk to infants aged 6 months and older or on medical indication, until the age of 24 months’. The formulation of this standard took 4 years and involved all stakeholders including the associations of food and beverages producing companies and baby-food producers, universities, professional organizations, non-governmental organizations (NGOs) and related government institutions.

Unfortunately, there is no category within this national standard for CFS. Therefore, the only commercially available food products falling under this category for infants and young children are instant cereals, biscuits and a few ready-to-cook products. All these products are currently fortified to some degree. The contents of these products comply with the national Codex standards as this is a prerequisite for the registration and marketing of these products. However, there is a concern that they could potentially interfere with continued breastfeeding because of the caloric content, recommended portion size and the recommended frequency of feeding, which are often not in line with best practices (Ten Year Strategy to Reduce Vitamin and Mineral Deficiencies MIYCN Working Group: Formulations Subgroup 2009). For example, there are products that are suggested for use from 4 months of age that are in line with existing national Codex regulations; however, relevant World Health Assembly resolutions subsequent to the International Code and other international guidelines identify 6 months as the appropriate age for the introduction of complementary foods. Examples such as this lead to understandable concern from the nutrition and child health community, and indeed all those who support optimal infant feeding and should be rectified.

The fortified infant cereals sold in Indonesia typically contain 200–210 kcal per portion of 40-50 g per serving and suggest multiple servings per day. This already exceeds the recommended energy intake from complementary foods for infants 6–8 months old who are breastfeeding and is almost half the requirement for children 12–23 months of age who are breastfeeding (Pan American Health Organization/World Health Organization 2003). Biscuits contain 78–90 kcal per serving and typically 6 g sugar (30%E)
in approximately 20 g per biscuit. This is in line with the National Codex that requires infant cereals to contain at least 0.8 kcal per gram and biscuits at least 4 kcal per gram (Head of the National Bureau of Standards 2005). National guidelines, however, should consider a lower limit for sugar (such as less than 10%) (Ten Year Strategy to Reduce Vitamin and Mineral Deficiencies MIYCN Working Group: Formulations Subgroup 2009) and lower the suggested serving sizes of complementary foods (e.g. 25 g) so as to ensure that these foods do not interfere with breastfeeding. Current pending revision of National Codex guidelines also suggests exclusion of products containing trans-fatty acids. Because it is currently not required that infant food labels contain information on trans-fatty acid content, it is likely that many products sold in Indonesia do contain trans-fatty acids.

Support and promotion of optimal IYCF practices

Both the MOH and NGOs/International organizations have extensively promoted breastfeeding, in particular exclusive breastfeeding for the first 6 months, and many policies and guidelines are in place to support optimal practices. However, there are still many hurdles to overcome as evidenced by the unsatisfactory exclusive breastfeeding rates. The rate of exclusive breastfeeding for children less than 6 months of age is just 32.4%, and continued breastfeeding at 2 years is 50.3% [Statistics Indonesia (Badan Pusat Statistic – BPS) and Macro International].

In contrast to breastfeeding interventions, complementary feeding interventions have been relatively neglected – perhaps because the messages are more complicated and more context specific than for exclusive breastfeeding. It is telling that the MOH has set behaviour change communications for improved complementary feeding as a goal in its National Action Plan for Food & Nutrition 2006–2010. It might be useful to set targets for complementary feeding practices such as increasing the percent of children 6–24 months of age who receive iron rich or iron fortified food (World Health Organization 2008).

Promoting CFS and protecting breastfeeding: what needs to be done?

CFS such as lipid-based nutrient supplements (e.g. Nutributter®) should be part of a larger strategy to combat childhood malnutrition, which also includes exclusive breastfeeding for 6 months, continued breastfeeding for up to 2 years and beyond, improved dietary diversity, appropriate frequency of feeding, and the inclusion of animal products in young children’s diets. As part of a broader nutrition strategy, CFS provide a powerful tool with which to address the poor dietary quality of the complementary diet (Adu-Alarwuah et al. 2007; Wang et al. 2007; Dewey et al. 2009; de Pee & Bloem 2009). In order to provide access to these products, barriers to use and promotion need to be addressed, and controls ensuring their proper use and promotion need to be in place.

Category in Codex

Many countries follow Codex Alimentarius when setting their national legislation, but Codex does not yet have a category under which CFS fall. Codex Alimentarius, therefore, needs to revise their texts to include a category for ‘complementary food supplements’: products that can supplement the nutritional content of locally accepted complementary foods. This category should at least include lipid-based supplements, and it could serve as a model for individual country standards.

As the revision of the Codex Alimentarius standards and guidelines is a lengthy process, it is possible for individual countries to initiate a process to revise their own national Codex to allow appropriate use of CFS. This has already been done in some countries. For example, there is a standard for fortified soy flour and for supplements for complementary foods in China.

Product registration

Currently in Indonesia, as in most countries, there is no special category for CFS such as MNPs or lipid nutrient supplements. Complementary foods can only be registered if they fall in one of four very distinct
categories: cereal-based, biscuits, ready-to-eat and ready-to-cook. This greatly limits companies’ opportunity to produce and market innovative products to reduce malnutrition as part of the local diet. Any food that is marketed for infants and young children has to fall under the current categories, and no other category allows for foods targeted at this group or any other particular age group.

However, there are two other categories under which CFS could fall: food supplements (as is currently the case with MNPs) or ‘foods for special uses’. As these are loosely defined and non-age specific, it is easier to fit a product in one of these categories. This has the advantage of providing wider access to products that help fill the nutrient gap of young children. Unfortunately, it also opens the way to uncontrolled and misleading promotion and marketing.

In order to be able to combine wide access to high-quality products designed to prevent malnutrition among vulnerable 6–24 months old children, and strict regulation as to the labelling and marketing of these products to prevent inappropriate use, it is essential that a new, specific category be defined for these products.

The establishment of the existing categories for complementary foods in Indonesia took 4 years. In order for the registration rules to be altered or for a new subcategory to be added, a long process needs to take place, including numerous meetings with experts in the field and all companies in the industry. It is, therefore, expedient for the public sector to initiate and manage the process of developing a new category for CFS.

**Clearly identify products as complementary foods rather than breast milk substitutes**

Once a category is created for CFS, products should be labelled and marketed in a manner such that they will be used solely as a complementary food and are not misused as a substitute for breastfeeding. In order to avoid misrepresentation of the product, certain guidelines emanating from the Code need to be followed:

- The age of introduction should not precede 6 months and should be clearly stated on all packaging.

<table>
<thead>
<tr>
<th>Age of child (months)</th>
<th>Energy needs from complementary foods (kcal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breastfed</td>
</tr>
<tr>
<td>6–8</td>
<td>200</td>
</tr>
<tr>
<td>9–11</td>
<td>300</td>
</tr>
<tr>
<td>12–23</td>
<td>550</td>
</tr>
</tbody>
</table>

If pictures are used, children should appear older than 6 months and show achievement of a physical or developmental milestone clearly reached after 6 months.

- Instruction should be given to serve the product with a daily ration of food that is less than the recommended daily energy intake from complementary foods for a breastfed child. Large servings (which are often now recommended for many infant cereals) would interfere with continued breastfeeding and, thus, act as a breast milk substitute. (See Table 1.)

- To further ensure that the product is not misused, the importance of exclusive breastfeeding for the first 6 months and continued breastfeeding to 2 years and beyond should be clearly stated in a conspicuous way on product packaging and in marketing messages.

- All marketing messages should make clear that the product is for children 6–24 months as well as make clear the points listed above.

These requirements are in keeping with the current wording in the International Code and subsequent World Health Assembly (WHA) resolutions. (World Health Organization 1981) (Quinn et al. 2010). Explicit national guidelines stating these requirements would help clarify which product is a complementary food to be promoted and which one serves as a breast milk substitute and is, therefore, subject to all marketing restrictions outlined in the Code. The national guidelines should also give guidance on which nutrition and health claims are acceptable for such products, if any.
Enforce the Code of Marketing of Breastmilk Substitutes

A landscape analysis of the health system was conducted in 2010, coordinated by the Ministry of Health and Bappenas (the National Planning Board) with technical and financial support of UNICEF, WHO and WFP Indonesia. One of the recommendations of this analysis was that a government regulation (in contrast to a decree which is less enforceable) should be approved to control the marketing of breast milk substitutes and develop a mechanism for monitoring and enforcement (Ministry of Health/Bappenas/UNICEF/WHO 2010). Without effective monitoring and enforcement systems to ensure compliance, legislation implementing the Code is of little value. Aguayo et al. (2003) found that comparable levels of Code violations were observed in Burkina Faso, where there is regulating legislation, and in Togo, where there is no legislation, and concluded that legislation must be accompanied by effective information, training and monitoring systems to ensure that healthcare providers and manufacturers comply with evidence-based practice and the Code. Improved education about, and enforcement of, the Code is critical both to protect breastfeeding as well as to responsibly allow for the necessary opening of a clearly defined space to promote appropriate complementary feeding in addition to breastfeeding for 6–24 months.

Discussion

Breastfeeding advocates have done an enormous job in getting breastfeeding on the Indonesian health agenda to the extent that exclusive breastfeeding for the first 6 months of life is now mandatory in Indonesia. In addition to protecting breastfeeding, the importance of timely, adequate and safe complementary feeding needs to be emphasized.

The Indonesian Code itself is not easy to interpret on the topic of complementary foods leaving it open to multiple interpretations that can, and do, result in irresponsible marketing of these products. Furthermore, it was not designed to address CFS, which did not exist at the time that the Code was drafted but have now been shown to be beneficial.

While previously the Indonesian government received funding for special health department activities from infant formula manufacturers, this policy has now been changed and existing contracts will be discontinued (Supriyono 2010). In line with WHA Resolution 58.32 (World Health Assembly 2005), the government will no longer use sponsor funds for its health activities from companies that produce breast milk substitutes but instead will work together with non-profit organizations such as WHO, UNICEF and others. These changes were necessary and should be applauded. Further government and multistakeholder action needs to be taken to fully implement and enforce the International Code of Marketing of Breastmilk Substitutes and ensure Baby-Friendly Hospitals are certified and follow the practices outlined in the 10 Steps to Successful Breastfeeding (World Health Organization & UNICEF 1989), including not distributing infant formula. Along with this, the government now needs to open the door for the private sector groups that comply with the Code of Marketing of Breastmilk Substitutes to develop and appropriately promote CFS for children aged 6–24 months in order to promote optimal development during the crucial 1000-day window of opportunity from birth to 2 years.

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Conflict of interest statement

No conflicts of interest have been declared.

References


Fortifying complementary foods with NaFeEDTA – considerations for developing countries

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Abstract

As a highly bioavailable iron compound, sodium iron (iii) ethylenediaminetetraacetate (NaFeEDTA) has been recommended as a food additive for fortification. The amount of a food additive that can be ingested daily over a lifetime without appreciable health risk is termed the acceptable daily intake (ADI). The ADI for NaFeEDTA is based on body weight. For complementary foods and food supplements for infants and young children in low-income countries, where prevalence of underweight is high yet nutrient needs are also high, it is not clear which doses might be appropriate. The objective is to calculate the dosage of NaFeEDTA for fortifying complementary foods assuming different population prevalences of underweight. Mathematical models were used to simulate the dosage of NaFeEDTA for 6- to 8-month-old infants under different prevalences of underweight ranging from 5% to 40%. In order to keep NaFeEDTA intake below the ADI for ethylenediaminetetraacetate (EDTA) recommended by the Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives for 95% of 6- to 8-month-old infants, the daily iron dose from NaFeEDTA in fortified complementary foods should be set between 2.2 mg and 1.8 mg in countries with a prevalence of underweight among 6- to 8-month-old infants between 5% and 40%, respectively. If 2 mg of iron is given to all 6- to 8-month-old infants, the percentage exceeding the ADI for EDTA would be <10% for populations with <30% of children who are underweight, which is the case for many countries. In conclusion, 2 mg of iron from NaFeEDTA could be used for fortifying one daily serving of complementary food to ensure EDTA levels are below the ADI for infants 6–8 months of age. An additional source of iron (such as ferrous sulfate) should be included to increase the iron dose to desired fortification levels.

Keywords: NaFeEDTA, fortified complementary foods, infant, underweight, developing countries.

Introduction

Iron deficiency is one of the most commonly recognized micronutrient deficiencies for infants and young children around the world. Iron deficiency can result in anaemia, abnormal psychological development and suboptimal physical work capacity (World Health Organization 2001). The causes of iron deficiency during infancy are related to high iron requirements for growth and relatively low iron content and poor bioavailability in complementary foods in low-income countries (Dewey 2007). The bioavailability of iron is low in plant-based complementary foods, and consumption of foods with high iron bioavailability such as meat, fish and poultry is generally inadequate in the developing world (Dewey 2007).
Iron-fortified complementary food is considered to be a cost-effective way to fulfil infants’ iron requirements. Fortification of complementary foods can be done at the site of manufacturer (e.g. a commercially prepared fortified porridge) or at home (e.g. home fortification with multimicronutrient powder [MNP] or fortified soy powder [Ying Yang Bao (YYB)]).

Various iron compounds are available for fortifying complementary foods, including ferrous sulfate, ferrous fumarate and electrolytic iron (Allen et al. 2006). As a highly bioavailable iron compound, sodium iron (iii) ethylenediaminetetraacetate (NaFeEDTA) has been recommended for food fortification (e.g. wheat flour, soy sauce, fish sauce and sugar) (Allen et al. 2006), and the relatively higher cost of NaFeEDTA is offset by its higher bioavailability, particularly in high-phytate diets. Some home fortificants (e.g. MNP and YYB) also use NaFeEDTA as their iron source. Like other EDTA and metal compounds, NaFeEDTA releases iron from EDTA salt in the gastrointestinal tract (mainly intestinal) (Heimbach et al. 2000). The iron is absorbed through a pathway similar to other non-haem iron. The EDTA absorption is independent of iron absorption (Heimbach et al. 2000). Thus, the safety concern for NaFeEDTA is similar to the concern for other metal-EDTA compounds (Heimbach et al. 2000).

The Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives (JECFA) states that the total intake of EDTA should not exceed acceptable levels (1.9 mg/kg body weight EDTA) after taking into account the intake of EDTA in the form of food additives based on EDTA compounds (JECFA 2007). Acceptable daily intake (ADI) is a measure of the amount of a food additive that can be consumed on a daily basis over a lifetime without an appreciable health risk. The ADI for NaFeEDTA is based on body weight, and body weight increases rapidly during 6–24 months of age. Complementary food recommendations are commonly grouped into 6–8 months, 9–11 months and 12–23 months. While the youngest children have a higher iron requirement, their weights are lower, and thus this puts them at greater risk of exceeding the ADI for EDTA.

In addition, the prevalence of underweight for children 6–24 months of age is high and varies across low-income countries (Black et al. 2008). Thus, it is not clear which doses would be appropriate for fortifying complementary foods for infants and young children in countries with high burdens of underweight. The purpose of the present analyses is to estimate the dose of NaFeEDTA used in iron-fortified complementary foods in countries with a high burden of underweight. Additionally, the methodology used here has implications for calculating levels of nutrients in foods for this target age group that are also based on body weight (e.g. essential fatty acids).

### Materials and methods

The distribution of z-score was simulated with normal function with a sample size (n = 10 000). The combined body weight distributions for 6- to 8-month-old male and female reference infants were constructed based on the Box-Cox power exponential method with the formula weight = (z-value*S*L+1)^1/L*M (de Onis 2006). The WHO Child Growth Standards parameters (L, M, S) were used for the calculation (de Onis 2006) where ‘L’ is the power transformation parameter for normal distribution, ‘M’ is the median of weight distribution and ‘S’ is the sample standard deviation.

The combined body weight distributions for 6- to 8-month-old infants in high burden countries were constructed under different levels of prevalence of

### Key messages

- Two milligrams of iron from sodium iron (iii) ethylenediaminetetraacetate NaFeEDTA could be used for fortifying one daily serving of complementary food to ensure ethylenediaminetetraacetate (EDTA) levels are below the acceptable daily intake for infants 6–8 months of age in many low-income countries.
- An additional source of iron (such as ferrous sulfate) should be included to increase the iron dose to desired fortification levels.
underweight ranging from 5% to 40%, which are typical for many low-income countries. Underweight was defined as weight-for-age z-score < −2 (de Onis 2006). Either mean changes or mean and variance changes were assumed for constructing a new body weight distribution. Both assumptions yielded similar results. Then the newly constructed weight distribution for each prevalence of underweight was used to calculate 2.5th and 5th percentile body weight. Based on the 2.5th percentile and 5th percentile body weight under each prevalence of underweight and ADI for EDTA (1.9 mg/kg body weight), the maximum amount of iron from NaFeEDTA was calculated.

RAND function in the Statistical Analysis System (SAS) was used for normal distribution simulation (SAS version 9.2; SAS Institute Inc., Cary, NC, USA).

**Results**

Based on Demographic and Health Survey data, the countries with prevalence of underweight between 5% and 40% are shown in Table 1. The combined 6–8 months boy and girl body weight distribution is shown in Fig. 1 with the 2.5th percentile, 5th percentile and median body weight at 6.14 kg, 6.41 kg and 7.97 kg, respectively. By increasing the rates of underweight in the model from 5% to 40%, the 2.5th percentile and 5th percentile body weight decreases from 5.83 kg to 4.76 kg and from 6.08 kg to 4.97 kg, respectively. In order to keep NaFeEDTA intake below the ADI for EDTA recommended by JECFA for 95% of 6- to 8-month-old infants, the daily iron dose from NaFeEDTA in fortified complementary foods cannot exceed 2.2 mg to 1.8 mg, correspondingly (Table 1). In order to keep NaFeEDTA intake below the ADI for EDTA recommended by JECFA for 95% of 6–8 months of age girls, the daily iron dose from NaFeEDTA in fortified complementary foods cannot exceed 2.2 mg to 1.7 mg, correspondingly (data not shown).

The overall prevalence of underweight in low-income countries is about 20%, and only a few countries in South Asia and East Africa have a prevalence ≥30%. If 2 mg of iron from NaFeEDTA were given to all 6- to 8-month-old infants, the percentage exceeding the ADI for EDTA would be <10% for

<table>
<thead>
<tr>
<th>Prevalence of underweight</th>
<th>Examples of countries with these prevalences</th>
<th>Body weight at 2.5th percentile (kg)</th>
<th>Body weight at 5th percentile (kg)</th>
<th>Maximum iron dose from NaFeEDTA (mg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>Congo Brazzaville, Lesotho, Swaziland, Namibia, Senegal, Zambia, Zimbabwe, Benin, Cameroon, Ghana, Sierra Leone, Haiti, Angola, Dominican Republic, Dominican Republic, Malawi, Madagascar, Nepal, Nigeria, Rwanda, Tanzania, Ghana, Malawi, Mozambique, Uganda, Burundi, Bangladesh, India</td>
<td>6.14</td>
<td>6.41</td>
<td>2.2</td>
</tr>
<tr>
<td>10%</td>
<td>Namibia, Senegal, Zambia, Zimbabwe, Benin, Cameroon, Ghana, Sierra Leone, Haiti, Angola, Dominican Republic, Dominican Republic, Malawi, Madagascar, Nepal, Nigeria, Rwanda, Tanzania, Ghana, Malawi, Mozambique, Uganda, Burundi, Bangladesh, India</td>
<td>5.31</td>
<td>5.60</td>
<td>2.1</td>
</tr>
<tr>
<td>15%</td>
<td>Benin, Cameroon, Ghana, Sierra Leone, Haiti, Angola, Dominican Republic, Dominican Republic, Malawi, Madagascar, Nepal, Nigeria, Rwanda, Tanzania, Ghana, Malawi, Mozambique, Uganda, Burundi, Bangladesh, India</td>
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<th>Body weight at 5th percentile (kg)</th>
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**Table 1.** Estimated iron dose (mg) from NaFeEDTA for 6- to 8-month-old children under different prevalences of underweight

**References**

populations with <30% of children who are underweight, which is the case for most of these countries (Table 2).

However, if 2.5 mg iron were given in NaFeEDTA form to all 6- to 8-month-old infants, 30–64% of infants would be above the ADI of EDTA. For infants 9–11 months, with the use of 2.5 mg, these figures are 5% and 30%, and for those 12–23 months, these figures are 1% and 8% (data not shown).

### Discussion

These analyses indicate that the daily iron dose from NaFeEDTA in fortified complementary foods should range from 2.2 mg to 1.8 mg to maintain EDTA intake below the ADI recommended by JECFA for 95% of 6- to 8-month-old infants, as prevalence of underweight of 6- to 8-month-old infants ranges from 5% to 40% in the statistical model. In low-income countries with various prevalences of underweight, 2 mg of iron from NaFeEDTA could be used for fortifying complementary foods for 6-to 24-month older infants and young children. This minimizes the risk of exceeding the ADI in infants 6–8 months of age. If a smaller portion size were suggested for the youngest infants (such as 1/2 portion per day), a higher level (such as 2.5 mg) could be used for young children 12–23 months of age, but then the infant would not receive sufficient quantities of the other nutrients.

The iron absorption rate from NaFeEDTA is about two to three times greater than that from either ferrous fumarate or ferrous sulfate in high-phytate
diets (Allen et al. 2006). This could be very effective for enriching complementary foods or complementary food supplements, as phytate content is generally high in cereal-based complementary foods [International Nutritional Anemia Consultative Group (INACG) 1993; Hurrell et al. 2000]. The dose of 1.8–2.2 mg iron from NaFeEDTA would provide about 0.18–0.22 mg absorbed iron, assuming 10% absorption based on MNP intervention studies and isotopic studies (Troesch et al. 2009; Troesch et al. 2011), which corresponds to 19–24% of iron requirements for 6- to 11-month-old infants and 31–38% of iron requirements for children aged 1–3 years (WHO/FAO 2004). Although this level still only meets about 1/5–1/3 of iron requirements for infants and young children, the EDTA could also enhance the absorption of food iron and soluble iron compounds from other sources (e.g. other iron fortificants) (Allen et al. 2006). However, this model also assumes consumption of a fixed daily serving and comparable absorption rates of iron in different settings. It does not take into account infection/inflammation and other factors that can affect iron absorption.

A recent study in South Africa showed that a MNP containing 2.5 mg of iron from NaFeEDTA significantly improved iron status (ferritin, transferrin receptor and body iron) and reduced iron deficiency of children aged ~8 years old when it was added to a maize porridge (Troesch et al. 2011). Another study provided 6 mg iron from NaFeEDTA to infants and young children through a fortified full-fat soy powder (YYB) in China (Wang et al. 2009). This was an intervention trial for older infants (n = 1478) and lasted until the children reached 24 months of age. YYB was given to an intervention group daily and a non-fortified isocaloric rice powder was given to a control group. The results found that YYB significantly decreased the prevalence of anaemia (Wang et al. 2009). MNP containing 2.5 mg of iron from NaFeEDTA was also used in a programme in the Kakuma Refugee Camp in Kenya to improve iron status in a malaria-endemic area (World Food Program et al. 2009). MNP was offered to children 6–59 months and to non-pregnant women for 13 months. At baseline, iron status was improved at the mid-term and endline, but anaemia did not decrease (Ndemwa et al. 2011).

During the complementary feeding period, body weight increases rapidly and iron requirements are lower at 12–23 months of age than at 6–11 months of age. If body weight of 12- to 23-month-old children is used for estimating NaFeEDTA dose for fortifying complementary foods (e.g. if 2.5 mg of iron from NaFeEDTA is given to children aged 12–23 months, 1–8% of the population under 5–30% of prevalence of underweight would be over ADI for EDTA.), there will be higher risk of intakes over the ADI for 6- to 11-month-old infants (e.g. if 2.5 mg of iron from NaFeEDTA is given to children aged 6–11 months, 30–64% of 6- to 8-month-old infants and 5–30% of 9- to 11-month-old infants under 5–30% of prevalence of underweight would be over ADI for EDTA). However, if body weight of 6-month-old infants is used for estimating the NaFeEDTA dose, the iron dose from NaFeEDTA would be relatively small for other older children. Thus, body weights of 6- to 8-month-old infants were combined for estimating the NaFeEDTA dose. The 6- to 8-month age group is commonly used for estimating energy and nutrient requirements from complementary foods (Dewey & Brown 2003). Although 6 mg of iron from NaFeEDTA was used in YYB in China and 2.5 mg of iron from NaFeEDTA was used in MNP in Kenya, there were no adverse effects (although the studies were not powered to assess adverse effects) reported in these two projects; 18–64% of 6- to 8-month-old infants would be over ADI of EDTA when 2.5 mg of iron from NaFeEDTA is given to infants and young children where the prevalence of underweight ranges between 5% and 30%.

In conclusion, 2 mg of iron daily from NaFeEDTA could be used for fortifying complementary foods without exceeding the ADI for EDTA for the majority of 6- to 24-month-old infants and young children in developing countries with varying prevalences of underweight. Because this level is below the iron reference nutrient intake (RNI), NaFeEDTA should be one part of the iron fortification used in complementary food and should be in addition to another good source of iron to reach the desired iron levels in the
complementary food. For example, in China, a complementary food supplement included 2.5 mg from EDTA iron and 2.5 mg from ferrous fumarate (Sun et al. 2011).

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Conflict of interest

No conflicts of interest exist.

References


Early child growth: how do nutrition and infection interact?

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Abstract

It is well known that the relationship between child nutrition and infection is bidirectional, i.e. frequent illness can impair nutritional status and poor nutrition can increase the risk of infection. What is less clear is whether infection reduces the effectiveness of nutrition interventions or, vice versa, whether malnutrition lessens the impact of infection control strategies. The objective of this paper is to review the evidence regarding this interaction between nutrition and infection with respect to child growth in low-income populations. Even when there are no obvious symptoms, physiological conditions associated with infections can impair growth by suppressing appetite, impairing absorption of nutrients, increasing nutrient losses and diverting nutrients away from growth. However, there is little direct evidence that nutrition interventions are less effective when infection is common; more research is needed on this question. On the other hand, evidence from four intervention trials suggests that the adverse effects of certain infections (e.g. diarrhoea) on growth can be reduced or eliminated by improving nutrition. Interventions that combine improved nutrition with prevention and control of infections are likely to be most effective for enhancing child growth and development.

Keywords: malnutrition, diarrhoea, environmental enteropathy, supplementary feeding, micronutrients, hygiene, stunting.

Introduction

Infections are very common in the first two years of life. For example, children under 2 years experience an average of three to five episodes of diarrhoea per year in developing countries (Fig. 1). In some countries, the rate is six to eight episodes per year. Diarrhoeal incidence peaks at 6–11 months of age as infants eat increasing amounts of complementary foods that may be contaminated. At this time, they begin to crawl and explore their environment, putting them in direct contact with multiple sources of pathogens. During an infection, the immune system requires a broad range of nutrients to mount a defence against the invading organism. It has been hypothesized that nutrition interventions targeting growth may not be effective if infections are prevalent. On the other hand, improved nutrition may strengthen the child’s ability to fight infection and reduce the negative effects of infection.

The objective of this paper is to review the available evidence on whether infection diminishes the positive impact of nutrition interventions on child growth and whether improved nutrition limits the
negative impact of infections on child growth—i.e. the interaction between nutrition and infection. Our purpose is not to examine the direct effect of nutrition on infection, which is a vast topic that goes beyond the scope of this paper. We begin with an overview of the relationship between child growth and the two most common categories of infection: diarrhoeal and respiratory infections. We then discuss the potentially growth-suppressing impact of subclinical infections and conditions, i.e. the ones that cause no obvious outward symptoms but may have important physiological effects. Next, we examine the evidence on whether there is an interaction between nutrition and infection with respect to child growth. We conclude with a brief discussion of the programmatic implications.

How strong is the impact of diarrhoeal and respiratory infections on child growth?

Diarrhoeal disease has many causes including pathogenic bacteria and other infectious microorganisms. In most cases, exposure to these pathogens occurs through the ingestion of contaminated food and water. Diarrhoeal illness is generally self-limiting,

Fig. 1. Episodes of diarrhoea per year among children under five (Margaret et al. 2003). Bars represent the 25th–75th percentiles across 20 countries (1990–2000).

Key messages

- Infections are very common in the first 2 years of a child’s life.
- Even when there are no obvious symptoms, physiological conditions associated with infections can impair growth by:
  - Suppressing appetite
  - Impairing absorption of nutrients and increasing nutrient losses
  - Diverting nutrients away from growth
- There is little direct evidence that nutrition interventions are less effective when infection is common. Further research is needed.
- Four intervention trials showed that the negative effects of diarrhoea on growth can be reduced or eliminated by improved nutrition.
- Interventions that combine improved nutrition with prevention and control of infections are likely to be most effective for enhancing child growth and development.
meaning that the infection will run its course and the child will return to normal without requiring specific treatment. However, severe or persistent diarrhoea and repeated exposure to pathogens that affect the gut can have serious consequences. Diarrhoea robs the child of fluids and certain key nutrients such as zinc and copper (Castillo-Duran et al. 1988). If these fluids and nutrients are not replaced, the result can be severe dehydration, malnutrition, growth faltering or death in extreme cases.

It is normal for children to exhibit growth faltering during a bout of diarrhoea and to grow more rapidly than usual (‘catch-up’ growth) after recovery, but the extent of ‘catch-up’ growth may depend on the age of the child, the child’s initial nutritional status, the specific pathogen(s) causing infection, the duration of the infection and the duration of the ‘diarrhoea-free’ interval following infection (Checkley et al. 1998; Wierzba et al. 2001). For example, children in Peru who were infected with the microorganism Cryptosporidium parvum experienced both weight and height growth faltering for several months post-infection followed by periods of ‘catch-up’ growth. Infants took longer to ‘catch-up’ in weight than children infected after 12 months of age, and those who were infected between birth and 5 months of age had a deficit of nearly 1 cm in height 1 year after infection, compared with non-infected infants (Checkley et al. 1998). Children who were already stunted (low height for age) at the time of infection did not catch up in either weight or height within 1 year after infection. Those who were not stunted at the time of infection achieved catch-up in weight within approximately 3 months and catch-up in height within approximately 6 months after infection, compared with their non-infected counterparts.

A high burden of diarrhoea in the first 2 years of life is associated with a much higher risk of stunting (height for age <−2 SD). In a pooled analysis of data from nine studies in five countries (Bangladesh, Brazil, Ghana, Guinea-Bissau and Peru), 25% of stunting at 24 months of age was attributed to having five or more episodes of diarrhoea in the first 2 years (Checkley et al. 2008). There was a ‘dose–response’ relationship between the cumulative burden of diarrhoea (e.g. proportion of days with diarrhoea) and the likelihood of being stunted at 24 months of age. Adjusting for socioeconomic status did not alter these results.

The impact of respiratory infections on growth is less clear, in part because of a paucity of research on this relationship. The most common types of respiratory infections – mild, upper respiratory infections – are unlikely to have persistent effects in most children. But respiratory infections that include fever are linked with a higher risk of stunting. In a longitudinal study of children in the Philippines followed from birth to 24 months of age, the cumulative impact of febrile respiratory infections on risk of stunting was similar to that of diarrhoea (Adair & Guilkey 1997). Fever is one indicator of immune system activation, which (as explained below) can suppress appetite and lead to re-allocation of nutrients away from growth.

**What is the role of subclinical infections and related conditions?**

An infection is defined as subclinical when there are no obvious signs or symptoms, but there is physiological evidence of abnormality. Young children often test positive for certain infections (e.g. Helicobacter pylori, Epstein–Barr virus, cytomegalovirus, mycobacteria, cryptosporidium and even HIV) without exhibiting clinical symptoms. Many children also carry malaria parasites or gastrointestinal parasites with no outward signs. Subclinical abnormalities of the gastrointestinal tract, presumably caused by frequent exposure to pathogens, are also thought to be common. Even though symptoms are not evident, these subclinical conditions may have a strong, perhaps cumulative effect on metabolic function and growth. Microorganisms in the gut play a critical role in these functions (Preidis et al. 2010). The types and relative amounts of different gut bacteria can be affected by the diet (De Filippo et al. 2010).

**Environmental enteropathy**

One subclinical condition that is likely to be prevalent in developing countries is environmental enteropathy (EE), also known as tropical enteropathy. This condition often has no outward manifestation but can cause nutrient malabsorption by changing the structure and function of the gut lining.

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One subclinical condition that is likely to be prevalent in developing countries is environmental enteropathy (EE), also known as tropical enteropathy. This condition often has no outward manifestation but can cause nutrient malabsorption by changing the structure and function of the gut lining.
function of the small intestine. It has been hypothesized that EE causes growth faltering and may decrease the efficacy of nutritional interventions (Goto et al. 2009; Humphrey 2009).

EE has been linked to living conditions with poor sanitation and hygiene practices, and is thought to be caused by chronic ingestion of pathogenic microorganisms. Gut exposure to high levels of harmful microorganisms results in a near-continuous state of immune system activation (see next section), which is harmful to the affected individual. Evidence that EE is related to sanitation and hygiene practices is provided by studies of Peace Corps volunteers and US soldiers stationed abroad who developed the condition during their assignments and regained normal intestinal function upon returning home. Research from the 1960s suggested that nearly all residents of the developing world at that time showed some signs of EE (Haghighi et al. 1997).

EE is characterized by various small intestinal abnormalities in seemingly healthy individuals. EE can be diagnosed by microscopic examination of an intestinal sample or by laboratory tests for intestinal permeability (sugar ratios present in the urine) or antibodies indicating that bacteria have been able to cross from the intestines into the body (endotoxin-core antibody). In healthy individuals, the surface of the small intestine is covered in millions of tiny, finger-shaped projections called villi. This architecture has evolved to maximize the surface area of the small intestine to facilitate nutrient absorption (Fig. 2). In a person affected by EE, changes occur in the structure of the small intestine including decreased villous height, sometimes referred to as ‘flat architecture’ (Fig. 3).

Not all people with EE will experience complete loss of villi; however, regardless of villous architecture, people with EE have increased intestinal inflammation and other structural changes that indicate an elevated immune response (Sullivan et al. 1991). EE is typically associated with a ‘leaky gut’ (increased permeability of the intestinal tract) and impaired ability to prevent pathogens from breaching the intestinal barrier.

The potential pathways by which fecal contamination leads to EE and subsequently to child undernutri-
Fig. 4. Pathways by which fecal contamination leads to environmental enteropathy and child undernutrition (Adapted from Humphrey 2009).
In a study in Peru, children in the worst conditions for sanitation and hygiene experienced 54% more diarrhoeal episodes between birth and 24 months of age and were 1 cm shorter at 24 months than children living in the best conditions. However, the association of water quality and sanitation with height was independent of the association with diarrhoeal disease. The investigators speculated that constant exposure to harmful bacteria could be causing EE and hindering the children’s ability to effectively absorb and utilize ingested nutrients, regardless of whether it caused diarrhoea (Checkley et al. 2004).

EE is probably far more common than overt diarrhoeal illness in such settings. In a cohort of children in the Gambia, increased intestinal permeability was identified in 76% of the 922 samples collected from 119 children between birth and 2 years of age, whereas children were reported to have diarrhoea on 7.3% of all days during this period (Lunn et al. 1991). Based on the negative correlation between intestinal permeability and monthly length gain (corrected for age), the investigators calculated that impaired intestinal permeability accounted for 43% of linear growth faltering during this period (Lunn et al. 1991). In a subsequent study (Campbell et al. 2003) in the same population, markers of intestinal function were normal at 2 months of age but deviated sharply from the norms by 15 months of age. The combined effects of three different markers of intestinal function were calculated to explain 56% of linear growth faltering. Because these were observational studies and the investigators did not control for potentially confounding variables, it is difficult to ascribe cause and effect, but the results point to the high prevalence of EE as a key risk factor for stunting in this population.

Immune activation, cytokines and appetite

In response to infection, the immune system becomes activated and produces specific immune cells and cytokines in large amounts to combat the invading organism. Cytokines are protein molecules that assist in fighting infection. They are beneficial in the short term; however, a chronic condition – like EE – can lead to continuously high levels of cytokines, which can cause negative metabolic consequences and suppress appetite (Wong & Pinkney 2004).

Reports of ‘poor appetite’ by caregivers of children under 2 in developing countries are common and may account for a substantial proportion of low energy intakes in this age group (Brown et al. 1995). Appetite is controlled by a group of chemicals called satiety hormones. Two important hormones involved in appetite regulation are ghrelin and leptin. Ghrelin stimulates food intake; leptin suppresses food intake. During infection, elevated levels of cytokines can lead to increased blood leptin concentrations and diminished appetite (Somech et al. 2007). This effect has been verified in cases of severe systemic infection such as neonatal blood infections (Orbak et al. 2003).

Immune system activation also lowers circulating levels of certain nutrients, in particular vitamin A and zinc, and increases iron retention in the liver, which restricts the availability of iron to other tissues in the body. These effects are probably part of an adaptive response to withhold key nutrients from invading pathogens, but they can result in inadequate availability of certain nutrients to support growth, even if intake is adequate, during the period of metabolic disturbance. Among children 6–20 months of age in Zambia, blood markers of inflammation (usually associated with infection) were negatively related to growth in length during the subsequent 3 months (Hautvast et al. 2000).

The ‘dirty chicken’ experiment

Studies of how sanitation affects the growth of newly hatched chickens provide clues that may be relevant to growth faltering of children in developing countries (Roura et al. 1992). A classic experiment conducted in 1992, called the ‘dirty chicken’ study, involved raising chicks in either steam-cleaned or unclean cages in close proximity with their own faeces. In each of the two living environments, the chicks were either administered an antibiotic cocktail or no antibiotics.

Unsurprisingly, living in close proximity to faeces in the poor sanitation environment caused the chicks raised without antibiotics to experience decreased
rates of weight gain, decreased efficiency of food utilization and increased levels of the cytokine plasma interleukin 1.

However, chicks raised in poor sanitary conditions and given antibiotics grew just as well and had the same low levels of circulating cytokines as chicks raised in steam-cleaned cages. The investigators concluded that the administration of antibiotics facilitated growth by preventing the immunologic stress and associated metabolic changes brought about by chronic exposure to faeces.

Researchers have attempted to treat EE in human children with antibiotics but with little success. In fact, in one study, provision of antibiotics led to an increased incidence of diarrhoea, perhaps due to a negative effect of antibiotics on the ‘good’ bacteria in the gut (Trehan et al. 2009). Short-term antibiotic therapy may fail because of re-exposure to fecal bacteria soon after treatment. Without improved sanitation and hygiene practices, a single course of antibiotics is unlikely to reverse EE, which may take months to resolve especially if there is repeated exposure to pathogens (Kirkpatrick et al. 2006; Thabane & Marshall 2009).

While prevention of infection-related growth faltering with antibiotics in humans may not be feasible, the ‘dirty chicken’ experiment indicates that living in poor sanitary conditions can cause growth faltering and implies that decreasing the burden of infection – including subclinical infection – may significantly improve growth outcomes.

What is the interaction between nutrition and infection?

Does infection make nutrition interventions less effective?

During infection, energy and other nutrients are diverted towards the immune response and away from growth. After all, survival is more important than continuing to grow, so growth faltering during infections may be an adaptive mechanism. However, repeated episodes of infection or persistent subclinical infection may put the child in a near-constant state of growth suppression. Does this mean that nutritional interventions for populations with high exposure to infections will be unsuccessful in improving child growth?

Evidence on this question is scant. In Indonesia, the effect of high-dose vitamin A supplements on linear growth in pre-school children (6–48 months of age) was dependent on the burden of respiratory infection (Hadi et al. 2003). In children with a low burden of respiratory infection, especially those with low vitamin A intake, linear growth improved after vitamin A supplementation. In children with a high burden of respiratory infection, there was little or no impact of vitamin A supplementation on growth regardless of vitamin A intake.

One potential explanation is that supplemental vitamin A is not well absorbed during an acute infection and a large proportion is excreted in the urine, rendering the high-dose supplement much less effective in improving vitamin A status if it is administered when the child is ill. Another potential explanation is that fever during respiratory infections causes metabolic changes that reduce circulating levels of vitamin A and make it less available to tissues to support growth. Regardless of the mechanism for the effect, the investigators concluded that coupling vitamin A supplementation programmes with efforts to reduce respiratory infections would increase the likelihood of a positive impact on growth.

Apart from the single study described above, there is little direct evidence that the impact of nutrition interventions is blunted when infections are common. Further research on this question is needed.

Does improved nutrition reduce the negative impact of infection?

The contrasting hypothesis is that improved nutrition can lessen or even eliminate the negative impact of infections on growth. The potential mechanisms by which improved nutrition could reduce the impact of infections on growth are shown in Box 1. These mechanisms include (1) strengthening the immune system; (2) compensating for malabsorption, reallocation or losses of key nutrients; (3) allowing for catch-up growth following infection; (4) enhancing appetite; and (5) favouring the growth of beneficial
gut microorganisms. Four nutrition intervention trials among pre-school children in Colombia, Guatemala, Tanzania and South Africa indicate that provision of macronutrients and/or micronutrients can limit the negative effects of diarrhoea on child growth.

**Randomized food supplementation study in Colombia, 1973–1980**

Families were eligible for food supplementation if the mother was in the first or second trimester of pregnancy and at least half of her pre-school-aged children were underweight (Lutter et al. 1989). All household members in the intervention group received protein-enriched food that included powdered skim milk. Children in all groups were supplemented with iron and vitamin A. For the analysis of child stunting related to diarrhoea, the investigators used data for 241 children followed for the first 3 years of life for whom they had complete morbidity data and measurement of height (length) at 36 months of age (148 unsupplemented children and 140 children who were supplemented from the sixth month of pregnancy up to 36 months).

Diarrhoea was very common in the Colombia study. The number of episodes from birth to 36 months was 18 in the unsupplemented group and 16 in the supplemented group (not significantly different). In the unsupplemented children, height at 36 months was strongly inversely associated with the number of days ill with diarrhoea (−0.03 cm for each day of illness, \( P < 0.001 \)). In the supplemented children, there was no relationship between diarrhoeal illness and height at 36 months (see Fig. 5, \( P < 0.001 \) for the interaction) (Lutter et al. 1992). The positive impact of supplementation on height (overall, approximately 3 cm) was greatest in children with the highest burden of diarrhoea (nearly 5 cm). The investigators concluded that nutritional supplementation eliminated the negative impact of diarrhoeal disease on child growth. They speculated that improved nutrient intake during and/or after illness episodes facilitated catch-up growth.

**Supplementary feeding intervention in Guatemala, 1969–1977**

A large supplementary feeding trial targeting pregnant and lactating women and their children from birth to 7 years of age was conducted in two sets of two matched villages. One village in each set was randomly selected to receive either a high-protein, high-energy supplement called 'Atole' or a non-protein low-energy supplement called 'Fresco', both fortified with several micronutrients (Martorell et al. 1995; Ramirez-Zea et al. 2010).

Among children 3–36 months of age who received Fresco, there was a significant negative relationship between the percentage of time with diarrhoea and length gain. By contrast, among children who received Atole, there was no significant relationship between diarrhoea prevalence and length gain (\( P < 0.05 \) for interaction effect) (Lutter et al. 1992). These findings were similar to those from the Colombia trial.

**Vitamin A supplementation in Tanzania, 1993–1997**

In this study, 687 children 6 to 60 months of age who had been admitted to the hospital with pneumonia were randomly assigned to high-dose capsules of vitamin A or placebo while hospitalized and, again, 4 and 8 months after discharge (Villamor et al. 2002).
There was no significant effect of vitamin A supplementation on growth for otherwise healthy children, but in children with persistent diarrhoea during the follow-up period, vitamin A eliminated the risk of stunting usually associated with this condition. Specifically, in the placebo group, the risk of stunting (adjusted for potential confounders) was 3.7 times higher in children with persistent diarrhoea than in those without persistent diarrhoea. In the vitamin A group, there was no risk of stunting associated with persistent diarrhoea ($P = 0.015$ for interaction effect). Children with persistent diarrhoea may have lower levels of circulating vitamin A than children with acute or no diarrhoea, so the vitamin A supplements may have compensated for this phenomenon and allowed for catch-up growth in children recovering from persistent diarrhoea. Although vitamin A is generally not considered a key growth-limiting nutrient (Golden 2009), ensuring adequate vitamin A may facilitate growth by restoring other physiological functions that must be normalized to permit rapid gain in lean tissue.

**Micronutrient supplementation in South Africa, 2003–2006**

In this study, 373 infants in three cohorts (32 HIV-infected children, 154 HIV-uninfected children born to HIV-infected mothers and 187 uninfected children born to uninfected mothers) were randomly assigned at 6 months of age to receive daily micronutrient supplementation for 18 months with either vitamin A, vitamin A plus zinc, or multiple micronutrients that included vitamin A and zinc (Chhagan et al. 2010). The study showed no overall impact on growth of zinc or multiple micronutrients compared with vitamin A alone (although there was a positive impact of multiple micronutrients on child length in those who were already stunted at enrolment). In the two cohorts of HIV-uninfected children, the addition of zinc or multiple micronutrients to vitamin A reduced the impact of repeated diarrhoea episodes on linear growth. This was most evident among children who had more than six episodes of diarrhoea per year ($n = 34$). In this subgroup, infants who received only vitamin A exhibi-
ited a decline of 0.6 z-scores in length for age between 6 and 24 months of age, but those who received multiple micronutrients showed no decline in length for age during the same interval (P = 0.06 within this subgroup of 34). The investigators suggested that the progressive stunting usually observed in children with repeated episodes of diarrhoea may be related to deficiencies of certain micronutrients, and could be prevented by adequate intake of those micronutrients.

These four studies all show that the negative effects of diarrhoea on growth can be offset by nutrition interventions, at least in these particular situations. However, as mentioned above, clinical symptoms of diarrhoea may be just the ‘tip of the iceberg’ when it comes to gastrointestinal conditions that can affect growth. EE may be much more prevalent than diarrhoea. Whether nutrition interventions can reduce or eliminate the growth-suppressing impact of EE is unknown.

In adults, however, there is some evidence that multiple micronutrients may partially reverse the impact of EE on gut function. In a study of intestinal impairment in Zambia, 500 adults (with or without HIV infection) were randomly assigned to receive multiple micronutrients or placebo for 2 years. Micronutrients had no impact on markers of intestinal permeability, but there was a significant reduction in one of the markers reflecting bacterial movement across the intestinal wall (Kelly et al. 2010). This suggests an improvement in gut integrity or immune function, but further research, particularly in children, is needed.

To date, there is almost no information on whether improved nutrition can reduce the impact of infections other than gastrointestinal infections, such as respiratory illnesses, and malaria on child growth, although the Tanzania study described above showed that vitamin A supplements were more effective for improving growth in children infected with malaria or HIV than in non-infected children.

Some nutrients, such as iron, have the potential to increase the risk of infection, or mortality due to infection, and may interfere with linear growth (Dewey et al. 2002; Hurrell 2010). The mode of administration, such as supplementation vs. fortification, and the initial iron status of the individual are key factors to consider when evaluating whether nutrition interventions that include iron are likely to reduce or exacerbate the influence of infection on growth.

Conclusions and programmatic implications

Infections play a major role in preventing children in developing countries from reaching their growth potential. A high burden of diarrhoeal disease is a key risk factor for stunting, and other types of infections also contribute to growth faltering, although their impact is not as well documented. However, the view that ‘disease rather than diet’ is the main cause of growth impairment (Campbell et al. 2003) ignores the important interaction between infection and nutrition. To date, the limited evidence available suggests that nutrition interventions can substantially reduce or even eliminate the negative effect of diarrhoeal disease on child growth. This is encouraging, but it should be recognized that subclinical conditions such as EE may account for a large proportion of growth faltering, and it is not yet known whether improved nutrition can prevent or reverse the deleterious effects of EE (or growth faltering associated with infections other than diarrhoeal disease).

At present, evidence is insufficient to conclude that high rates of infection make nutrition interventions ineffective for improving child growth. Only one study was found that supported this hypothesis (Hadi et al. 2003). In this study, a high burden of respiratory infection limited the potential for vitamin A supplementation to improve growth. Clearly, further research on this issue is needed, but a single study involving a single micronutrient does not warrant holding back on efforts to improve nutrition in populations where infections are prevalent.

Nonetheless, combining improved nutrition with efforts to prevent and control infections will likely be the most effective approach for optimizing child growth and development (Box 2). This question was explored many years ago in the Narangwal Nutrition Experiment conducted between 1969 and 1973 in Punjab, India (Kielmann et al. 1983). In that project,
10 villages were selected in clusters of two to three villages to receive a package of services that included either nutrition care (NUT), health care focused on infection control (HC), integrated services including both nutrition and health care (NUTHC) or standard care (control – symptomatic health care on demand only). NUT services included growth monitoring, food supplementation (initially only for malnourished children, but later made available to all children) and nutrition education. Health care services included curative and preventive care for common illnesses, immunizations and hygiene education. The target group was children under 3 years of age. At 36 months of age, children in the NUT or NUTHC villages were 1.3 cm taller than children in control villages, with no significant difference between NUT and NUTHC villages. Children in HC villages were taller than those in control villages, but not as tall as children in the NUT or NUTHC villages. Thus, in this setting, the combination of nutrition and health care did not produce a greater improvement in growth than nutrition care alone. However, the psychomotor development scores of children in the NUTHC villages generally exceeded the summed separate effects of NUT and HC, suggesting a synergistic effect on those outcomes. Apart from the Narangwal experiment, very little information exists on whether providing infection control together with direct nutrition interventions has an additive or synergistic effect on child growth or other key outcomes.

Key components of infection control are effective promotion of handwashing with soap and water and improvements in sanitation and water quality, which can significantly decrease diarrhoeal disease. In a recent meta-analysis (Cairncross et al. 2010), handwashing was linked to a 48% risk reduction of diarrhoea across study designs and pathogens. A substantial positive effect was also found for both water quality and sanitation improvements – 17% and 36% risk reductions, respectively. Access to and utilization of toilets is a high priority (Humphrey 2009), yet an estimated 2.6 billion people globally live without basic toilets to dispose of faeces (Coombes 2010).

An essential element of combined approaches is the promotion of breastfeeding for at least 2 years (exclusively for the first 6 months, and continued breastfeeding in combination with nutritious complementary foods thereafter), which has the dual benefit of reducing infection and improving nutrition. Other key practices, highlighted in the *Guiding Principles for Complementary Feeding of the Breastfed Child* (PAHO/WHO 2003), are feeding during and after illness to sustain adequate nutrient intake and promote catch-up growth, and safe preparation and storage of complementary foods to reduce food-borne illnesses.

Although many nutrition programmes already include hygiene messages, simply increasing knowledge and awareness about behaviours such as handwashing is not enough. Sustainable changes in behaviours are more difficult to achieve because of factors such as lack of access to clean water, long distance from water sources, the cost of hygiene products and poor design of educational interventions that do not take into account cultural beliefs or craft messages tailored to the needs and values of the target audience (Luby et al. 2008; Arnold et al. 2009; Aunger et al. 2009; Biran et al. 2009). The difficulty of improving household hygiene and sanitation practices, outside of intensive efficacy trials, is well recognized by researchers (Curtis 2003; Luby et al. 2008; Scott et al. 2008; Arnold et al. 2009; Luby et al. 2009). Innovative strategies have been suggested that focus on emotional motivations for behaviour change and engagement of professional consumer and market research agencies, rather than relying solely on knowledge-based approaches (Curtis 2003; Biran et al. 2009).

Research is needed on the efficacy and effectiveness of approaches that combine nutrition interven-
tions with multiple strategies for prevention and control of infections, including hygiene education, improvements in water quality and sanitation and measures to prevent and treat respiratory illness and other infections such as malaria. Development and evaluation of integrated cost-effective programmes designed to tackle these multiple objectives should be a high priority.

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Conflicts of interest

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