alive&thrive
nourish. nurture. grow.

Insight

A&T Technical Brief
Issue 7, November 2013

Strategies for ensuring adequate nutrient intake for infants and young children during the period of complementary feeding

Kathryn G. Dewey and Bineti S. Vitta

Introduction

The "1,000 days" period that encompasses pregnancy and the child's first two years after birth is considered the key window of opportunity for preventing undernutrition and its long-term consequences.[1] The largest part of this window is the complementary feeding period (6-24 months), the period of transition from exclusive breastfeeding to consuming a wide range of foods in addition to breastmilk.[2, 3] Although considerable growth faltering can occur during the prenatal period and the first 6 months after birth, a large proportion of stunting in low-income countries occurs during this 18-month interval.[4-6]

Inadequate nutrient intake from complementary foods and the high incidence of infections during this age interval in disadvantaged populations are major causes of stunting and other adverse health and developmental outcomes.[7] Consequently, ensuring adequate nutrition during the complementary feeding period is a major global health priority. However, it is a challenge to meet nutritional needs during this age interval.

The objectives of this brief are to explain why nutrient shortfalls are so ubiquitous during the period of complementary feeding and discuss options for closing those gaps. Specifically, the paper will 1) examine why infants require a much

Key Messages

1. Children under two years of age have high nutrient needs to support growth and development but typically consume relatively small amounts of food. For this reason, complementary foods need to be high in nutrient density (i.e., the amount of each nutrient per 100 kcal).

2. Complementary foods need to be far more nutrient-rich than foods consumed by adults in the household, yet often the opposite is the case in low-income households – i.e., infants are typically fed watery porridges that are low in many of the key nutrients. Per 100 kcal of food, a breastfed infant at 6-8 months of age needs more than 4 times as much zinc and 9 times as much iron as an adult male.

3. Typical complementary food diets in developing countries are often inadequate in multiple micronutrients, but nutrient gaps are usually largest for iron and zinc.

4. Complementary food diets of pre-agricultural populations (before the agricultural revolution ~10,000 years ago) were probably much higher in many key nutrients than is true of diets in low-income populations today. The adoption of agriculture resulted in a shift from varied diets rich in animal-source and wild plant foods towards the consumption of cereal grains and other starchy foods, and was accompanied by a deterioration in nutritional status in many parts of the world.

5. A food-based approach for improving child nutrition is generally preferable, as it can address the needs for multiple micronutrients as well as high-quality macronutrients. However, it is difficult to meet iron and zinc requirements with non-fortified nutrient-rich foods (such as meat, poultry, and fish) because they are often prohibitively costly to low-income households.

6. There are several options for improving dietary adequacy. One is to promote increased intake of key nutrients from local foods including certain indigenous foods that are currently under-utilized as complementary foods. Another is improving access to specialized fortified products for infants and young children: fortified blended foods, micronutrient powders, and complementary food supplements. Each of these options has advantages and disadvantages, so the best choice depends on the context. The provision and/or marketing of fortified products should be coupled with educational messages on breastfeeding and complementary feeding.

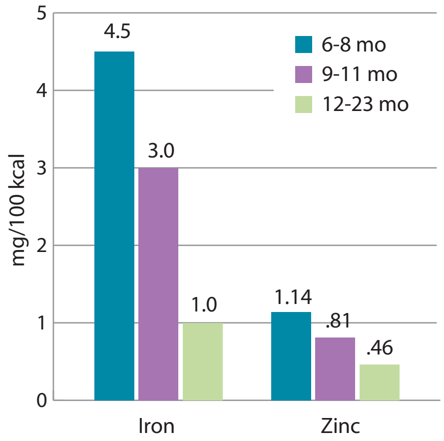
higher quality diet than other members of the household, 2) identify the nutrient gaps in typical complementary food diets, 3) describe strategies for achieving adequate nutrient intake at 6-24 months of age in low-income countries, including the use of fortified products, and 4) briefly identify the issues that need to be addressed when considering the use of fortified products for complementary feeding.

Challenges to ensuring adequate nutrition at 6-24 months of age

Children under two years of age have high nutrient needs to support growth and development. Because breastfed infants typically consume relatively small amounts of foods other than breastmilk, complementary foods need to be very high in nutrient density, i.e., the amount of each nutrient per 100 kcal of food. At 6-8 months, average expected energy intake from complementary foods is only ~200 kcal/day (assuming average breastmilk intake in developing countries,[3] and as a result, the minimum target nutrient densities in those foods tend to be the highest at that age, especially for iron and zinc (**figure 1**).

Average expected intake from complementary food rises to ~300 kcal/

Figure 1: Minimum target iron and zinc density of complementary foods



Calculations: Minimum target nutrient density of complementary foods = [(nutrient requirement – amount of nutrient provided by breastmilk) ÷ energy required from complementary foods] * 100

Data sources: iron requirements,[56] zinc requirements,[57] energy content of breastmilk,[58] iron content of breastmilk,[3] zinc content of breastmilk,[59] energy required from breastmilk and energy required from complementary foods[2]

day at 9-11 months, so target nutrient densities are lower for breastfed infants at 9-11 months than at 6-8 months. In the second year of life, the minimum target densities of complementary foods for certain nutrients like iron, zinc, and calcium are lower than they are in the first year because the average expected energy intake from complementary foods rises further to ~550 kcal/day (and for iron, total requirements go down). Thus, the second six months of life is the age interval during which meeting micronutrient needs poses the greatest challenge.

To illustrate the need for nutrient-dense complementary foods, **figures 2a and 2b** compare the target nutrient density for complementary foods for a 6-8-month-old breastfed infant with the target nutrient density for the diet of an adult male who consumes 2700 kcal/day. Per 100 kcal of food, 6-8-month-old breastfed infants need more than four times as much zinc and nine times as much iron as an adult male. This means that complementary foods need to be far more nutrient rich than the foods consumed by adult males, yet often the opposite is true in low-income households. Adult males may get first priority for meats and other nutrient-rich foods while infants are typically fed watery porridges that are low in many of the critical nutrients.

Abbreviations

DHA	docosahexaenoic acid
MNP	micronutrient powder
LNS	lipid-based nutrient supplement
LP	linear programming
PUFA	polyunsaturated fatty acid
SQ-LNS	small-quantity lipid-based nutrient supplement

Nutrient gaps in complementary food diets

Several studies have identified "problem nutrients" during the complementary feeding period. In developing countries, protein density is generally adequate, but the usual problem nutrients include iron and zinc. Other nutrients may also be low depending on the types of foods consumed (e.g., riboflavin, niacin, thiamin, folate, vitamin B6, vitamin B12, calcium, vitamin A, vitamin C, and vitamin E) or the water and/or soil content where the foods are grown (e.g., iodine, selenium). Diets that are predominantly based on grains and legumes are usually high in phytate, which limits the amount of bioavailable iron, zinc, calcium, and phosphorus that the child can absorb.

Using data sets from six countries (Bangladesh, Ghana, Guatemala, Peru, Mexico, and the United States), Dewey and Brown compared the median nutrient density of complementary foods consumed by breastfed children to desired nutrient densities (assuming an average breastmilk intake).[2] At 6-11 months, calcium, iron, and zinc densities of actual diets were below desirable levels in all countries with data for that

Figure 2a: Comparison of minimum target nutrient densities for vitamins between 6-8-month-old infants and adult males

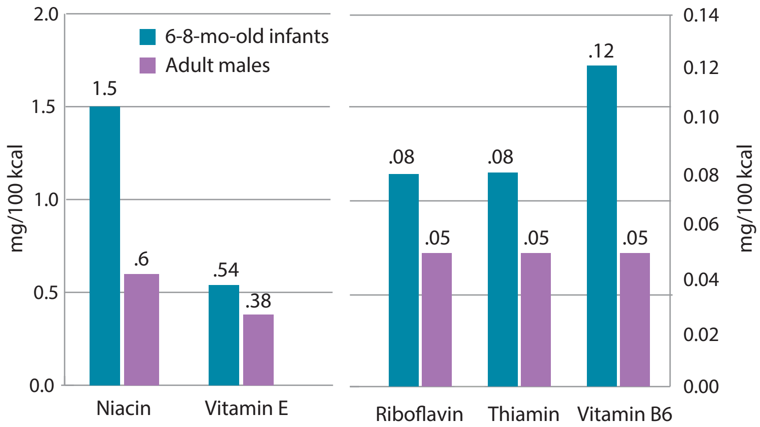
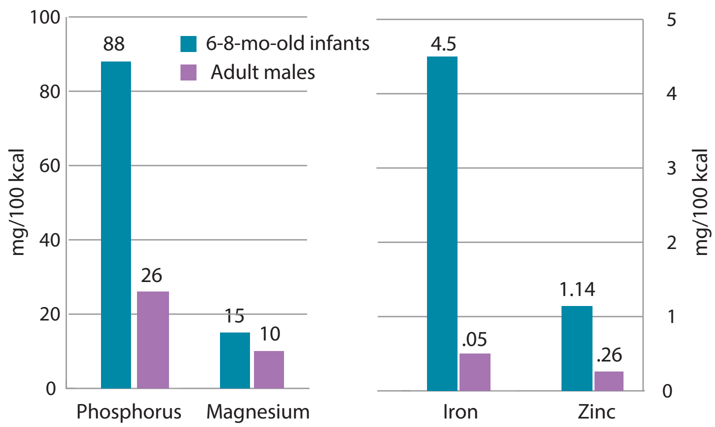


Figure 2b: Comparison of minimum target nutrient densities for minerals between 6-8-month-old infants and adult males



Calculations: Minimum target nutrient density of complementary foods = [(nutrient requirement – amount of nutrient provided by breastmilk) ÷ energy required from complementary foods] * 100; Minimum target nutrient density for adults = nutrient requirement ÷ energy requirement *100

Data sources: *Minimum target nutrient densities for adult males*: vitamin requirements,[56] phosphorus requirements,[60] energy requirements;[61] *Minimum target nutrient densities of complementary foods consumed by 6-8-month-olds*: vitamin, magnesium, and iron requirements,[56] phosphorus requirements,[60] zinc requirements,[57] energy content of breastmilk,[58] nutrient content of breastmilk,[3] zinc content of breastmilk,[59] energy required from breastmilk and energy required from complementary foods[2]

age. At 12-23 months, calcium and iron densities were generally low, but zinc density was adequate. Densities of vitamins A and C were low for some but not all countries and age groups. For the majority of B vitamins examined (i.e., thiamin, riboflavin, niacin, B6, and folate), nutrient density was generally lower than desired except in the U.S. These analyses suggest that multiple micronutrients are likely to be inadequate in the complementary food diets of children in developing countries.

Using "best case scenario family food menus" from low-income households in Guatemala, Vossenaar et al.[8] showed that the nutrient density of the hypothetical infant diet comprised of family foods that were nutritionally adequate for the rest of the household (plus breastmilk) would be far below the critical nutrient density (as defined by the authors) for calcium, iron, and zinc across the entire age range of 6-24 months, and below the critical nutrient density for some of the vitamins in certain age intervals.

In Zimbabwe, Paul et al. assessed the feasibility of improving infant diets using only locally available resources and feeding messages.[9] Although intakes of iron and zinc from complementary foods increased after counseling, they still fell far short of recommended intakes.

Using linear and goal programming to develop complementary food recommendations for 9-11-month-old Indonesian infants and to identify nutrients that would likely remain low in their diets, Santika et al.[10] found that iron requirements could not be achieved using local food sources (the highest level achievable was 63 percent of recommendations), and adequate levels of zinc were difficult to achieve.

Using linear programming techniques to maximize the chances of meeting nutrient needs (see **box 1**), Vitta and Dewey analyzed hypothetical complementary food diets comprised of local unfortified foods available in Bangladesh, Ethiopia, and Viet Nam.[11] Those analyses showed that there would be gaps in iron and zinc intakes unless unrealistic amounts of liver were part of the daily diet. (See "Technical paper": Identifying micronutrient gaps in the diets of breastfed 6-11-month-old infants in Bangladesh, Ethiopia, and Viet Nam). **Figures 3a and**

3b illustrate the gaps in iron and zinc when the hypothetical complementary food diets included egg plus fish or chicken every day along with grains, legumes, and green leafy vegetables.

Although it is difficult to meet the nutritional needs of infants and young children with modern cereal-based unfortified diets, estimates based on presumed food intake of hunter-gatherers suggest that diets of infants and young children before the agricultural revolution ~10,000 years ago were much higher in many nutrients.[12] Pre-agricultural humans consumed a wide variety of animal-source foods and wild plant foods, while cereal grains and legumes were rarely consumed as they were tedious to collect and process. Estimates of the nutrient intakes of infants and young children in pre-agricultural societies, based on breastmilk and premasticated foods provided by their mothers, suggest that the typical pre-agricultural diet was probably more than adequate to meet nutrient requirements. The agricultural revolution resulted in a dramatic shift in human diets towards consumption of cereal grains and other starchy foods, which was accompanied by a deterioration in nutritional status in many populations and a reduction in average adult height. **Figures 4a and 4b** illustrate that while the pre-agricultural complementary feeding diet was probably able to meet iron and zinc needs, modern day diets fall short.

Shortfalls in iron and zinc are of concern because these nutrients play important roles in numerous metabolic functions and hence are essential for optimal growth, immune function, and child development. Early iron deficiency alters brain development[13] leading to poor cognitive, motor, social-emotional, and neurophysiologic outcomes in the short- and long-term.[14, 15] Consequences of early zinc deficiency include diarrhea and respiratory infections, poor growth and development, impaired cognitive function, and problems with behavior or learning.[16] Iron deficiency is very common among infants and young children, particularly in low-income populations,[17] and it is estimated that 27 percent of children suffer from anemia due to iron deficiency.[18] There are currently no estimates for the global prevalence of zinc deficiency among children, but global prevalence of zinc deficiency among all age groups is estimated to be 17 percent[19] with a higher prevalence among children under 2 years of age.

Figures 3: Percentage of iron and zinc needs met by the "5 food group, unfortified" complementary food diets of infants in Bangladesh, Ethiopia, and Viet Nam

Figure 3a: 6-8-month-old infants

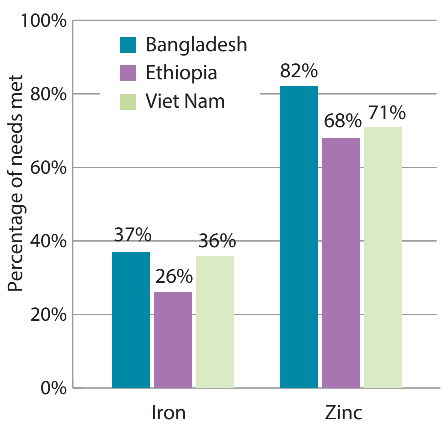
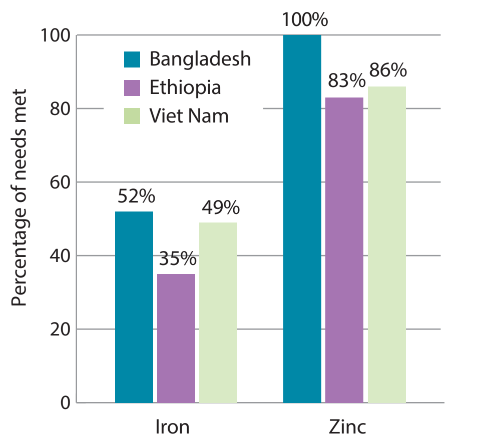


Figure 3b: 9-11-month-old infants



The "5 food group, unfortified" complementary food diets consisted of 30 percent of energy from the country's typical staple food (rice for Bangladesh and Viet Nam, corn bread for Ethiopia) and 25 percent of energy from legumes, 20 percent of energy from chicken egg, 20 percent of energy from fish for Bangladesh and Viet Nam and chicken for Ethiopia, and 5 percent of energy from green leafy vegetables.[11]

Box 1

Linear Programming

Linear programming is a mathematical method for determining the optimal outcome given certain constraints. It can be used to develop diets that meet nutritional requirements at the lowest possible cost. While this method has been used for decades to design optimal feeding diets for domestic animals, it has only recently been applied to human diets. For a given population, the only information needed is a list of locally available foods, their nutrient contents, their costs, and the typical or maximum amounts of each food consumed by the target group. The assumptions and constraints can be tailored to the target population (e.g., energy and nutrient requirements). The Optifood software developed by WHO uses linear programming, and the ProPAN tool developed by PAHO to improve infant and young child feeding (www.PAHO.org/ProPAN) can generate outputs for use in the Optifood program.

Figure 4a: Estimated iron intake at 9-11 months

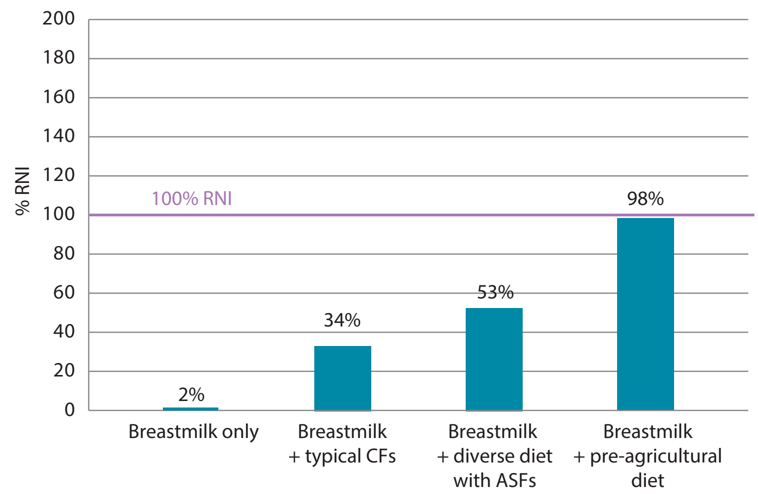
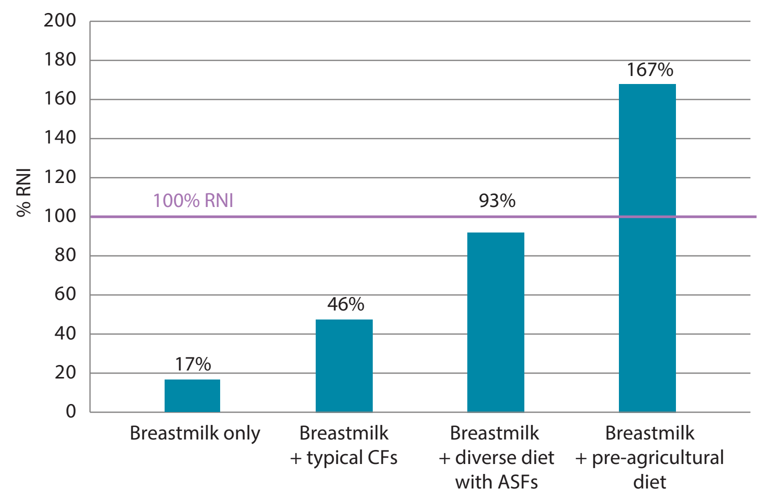


Figure 4b: Estimated zinc intake at 9-11 months



*Used with permission. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. J Nutr. 2013.

Definitions: *Typical complementary foods* (CFs): Average of typical general food distribution rations provided by the World Food Program's Emergency Operations,[62] which include grain (rice, corn, wheat, or sorghum), pulses and vegetable oil). *Diverse diet with animal-source foods* (ASFs): Average of "five food group" diets from Bangladesh, Ethiopia, and Viet Nam consisting of the country's staple food, legumes, chicken egg, fish or chicken, and green leafy vegetables.[11] *Pre-agricultural diet:* Average values for the nutrient content of the types of foods likely consumed by hunter-gatherers and nutrient content of the composite pre-agricultural diet taken from Eaton & Eaton 2000.[63] Eaton & Eaton's composite pre-agricultural diet is based on 35 percent of energy from animal-source foods and 65 percent from plant-source foods, and uses nutrient content data for 85 wild animal food sources and 236 wild plants that have been utilized by recent hunter-gatherers.[64] For wild game, they averaged nutrient values from all species; for plant foods they used a weighted average based on forager diets in eastern and southern Africa. In both cases, they excluded food sources that had extreme outlier values for any of the nutrients.

Data sources: iron content of breastmilk,[3] zinc content of breastmilk,[59] iron and zinc content of typical complementary foods,[62] iron and zinc content of diverse diet with animal-source foods,[11] iron and zinc content of pre-agricultural diet[63]

Strategies for achieving adequate nutrient intake at 6-24 months of age

Food-based approach vs. nutrient supplementation

Until recently, the main strategy promoted for tackling micronutrient deficiencies in young children was supplementation with one or a few key micronutrients. High-dose vitamin A capsule distribution programs are a good example of a low-cost strategy that can achieve a notable reduction in a nutrient deficiency on a relatively large scale.[20] But it has long been recognized that improved dietary quality is the preferred long-term solution. Researchers have observed that populations with a high prevalence of vitamin A deficiency or iron deficiency are likely to suffer from multiple micronutrient deficiencies, so providing only one or even a few of the essential nutrients at a time is not the ideal approach.

When it comes to promoting healthy child growth, all of the nutrients essential for growth must be provided in the required amounts at the same time. If any one of them is deficient, the rate of growth will be constrained by the most limiting nutrient. This feature is a key defining characteristic in the categorization of Type I and Type II nutrients:[21]

- *Type I nutrients* are those needed for specific biochemical functions. If there is a deficiency, a child will show clinical signs or symptoms but *not necessarily reduced growth*. Type I nutrients include vitamins as well as iron, iodine, selenium, and calcium.

- *Type II nutrients* are the "growth nutrients," i.e., the building blocks of tissue. If there is a deficiency in any of them, a child will exhibit reduced growth. It is difficult to test for deficiencies of Type II nutrients because growth faltering is a non-specific symptom. Type II nutrients include protein, sulfur (a component of the amino acids that make up protein), potassium, magnesium, phosphorus, zinc, and sodium.

A nutritionally complete, food-based approach that includes both Type I and Type II nutrients is more likely to be successful at resolving multiple micronutrient deficiencies and promoting healthy child growth as well as laying the foundation for healthy food choices over the lifespan than programs based on supplementation with only one or a few micronutrients. A food-based approach makes it possible to tackle not only micronutrient quality, but also the adequacy of macronutrients including high-quality protein and essential fatty acids. Of course a key issue is cost, since single nutrient supplements are much less expensive than nutrient-rich foods.

Increased intake of non-fortified nutrient-rich foods, e.g., animal-source foods

To what extent can nutrient gaps be narrowed by increasing intake of non-fortified nutrient-rich foods? Most of the research on this question has focused on increasing intakes of iron and zinc, which are usually the most limiting nutrients at this age. A systematic review of complementary feeding interventions[22] indicated that educational approaches had a positive impact in some but not all studies, with an average increase of 24 percent (range: 7-60 percent) in iron intake and 26 percent (range: 9-53 percent) in zinc intake from complementary foods. Despite those increases, mean iron and zinc intakes from complementary foods were still well below recommended intakes in most sites. A recent randomized trial conducted in India[23] confirms the difficulty of meeting iron and zinc needs via educational approaches alone. While the intervention resulted in a 33 percent increase in iron intake and a 75 percent increase in zinc intake from complementary foods at 9 months of age (compared to the control group), the intakes of the intervention group remained well below the desired amounts (intake of 0.9 mg/day of iron, relative to a desired intake of 9.1 mg/day; intake of 0.7 mg/day of zinc, relative to a desired intake of 2.3 mg/day).

The modest impact of educational approaches is not surprising when considering the barriers to large increases in intakes of iron- and zinc-rich foods by infants in low-income populations. The richest sources of these nutrients are animal-source foods, particularly flesh foods and organ meats. In most low-income populations, infants consume animal-source foods rarely and in small amounts. To illustrate this, **table 1** shows data from Uganda for children 6-23 months of age. Apart from dairy products (which are typically low in iron), consumption of animal-source foods was infrequent (5-19 percent of days for meat and poultry; 19-25 percent of days for fish; 9-12 percent of days for eggs). When consumed, the average intake was 1-2 tablespoons of meat/poultry, < 1 tablespoon of fish and about 2 tablespoons of egg. Increasing these quantities is costly and would require that intake of the staple complementary food (e.g., cereal-based porridge) be decreased so that total energy intake from complementary foods does not exceed the recommended amount and displace breastmilk. For example, to meet the level of meat intake that satisfies zinc requirements at 9-10 months of age (~60 g/day when prepared with some water),[24] meat intake of Ugandan infants (6-11 months) would need to be much higher than shown in table 1.

In an analysis of 26 indigenous recipes for complementary foods, Gibson et al.[25] found that only the recipes including chicken liver, egg, or fish had a phytate:iron ratio that was sufficiently low (< 1) to facilitate iron absorption, but even those recipes did not provide enough iron to meet requirements at a consumption level of ~200-300 kcal/day. Several investigators are exploring the feasibility of increasing consumption of

Table 1: Consumption of animal-source foods by infants and young children in Uganda (n=377)*

FOOD	% OF DAYS CONSUMED			MEDIAN G/D ON DAYS CONSUMED		
	6-11 mo	12-17 mo	18-23 mo	6-11 mo	12-17 mo	18-23 mo
Dairy products	40	42	30	150 (liquid)	155 (liquid)	173 (liquid)
Meat & poultry	5	14	19	15	31	42
Fish	19	24	25	17	9	12
Eggs	12	9	12	32	28	28

*Data from Christine Hotz and the HarvestPlus team, analyzed by Mary Arimond.

meat (beef and pork) and chicken liver by infants in low-income countries.[26, 27] However, in a cluster-randomized trial in four countries in which freeze-dried beef was provided daily to infants from 6 to 18 months of age, 27 percent of infants in the beef group had iron deficiency (based on low serum ferritin) at 18 months of age, compared to 15 percent in the group receiving a fortified infant cereal.[26] This suggests that the amount of iron provided by the daily ration of beef (1.4 mg Fe at 6-12 months and 2.1 mg Fe at 13-18 months)[28] was not sufficient.

There is potential for increased intake of key nutrients from certain indigenous foods that are currently under-utilized as complementary foods.[29] For example, some insects such as caterpillars are comparable in nutrient content to beef.[30, 31] Certain species of small fish, when consumed whole with bones, heads, and viscera, are very high in iron, zinc, and vitamin A.[32] A condiment made from fermented seeds from a native tree in Burkina Faso, soumbala, is very high in iron and can be used to enrich local complementary foods.[33] These types of foods may already be eaten in reasonable quantities by adults, but are typically not fed to infants. Research to evaluate the potential for such foods to augment the nutritional quality of complementary food diets is underway.

Although it is commonly assumed that indigenous foods are low cost, this may or may not be the case once the opportunity costs such as caregivers' time for gathering and processing the foods are taken into account. Women in low-income countries often have heavy workloads, which means that the convenience of obtaining and preparing complementary foods may be a high priority.[34]

Fortified products for complementary feeding

Options for fortification

For infants and young children, fortification of staple foods that are consumed by the general population such as wheat flour, maize, and rice is unlikely to close a significant portion of the "gap" in micronutrient intake from complementary foods, particularly for iron and zinc. This is because children under two years of age consume only 200-550 kcal of complementary food per day. To meet their iron and zinc needs, the staple food would have to be fortified at a very high level so that the recommended intakes could be achieved with a daily ration of only 30-40 g/day (dry flour). Such high levels of fortification would lead to excessive intakes, especially for iron, in other age groups, such as adult men. For this reason, specialized products targeted at infants and young children have been developed. Fortified products for complementary feeding have been categorized into three general types:[35] a) fortified blended foods, b) micronutrient powders, and c) complementary food supplements.

Fortified blended foods, such as corn-soy blend, are defined as products that are used as a replacement for the traditional local porridge or in addition to traditional porridge. They are typically made from cereals, legumes, and sugar or oil and fortified with certain micronutrients, but some have been developed to include milk, additional fat sources providing essential fatty acids, high-quality protein, and/or macrominerals such as calcium and phosphorus. Fortified blended foods that are pre-cooked are convenient because they require little preparation time. In addition, the use of central processing facilitates quality control. There are some disadvantages to using fortified blended foods as the main strategy for improved nutritional quality of complementary foods. First, it is difficult to ensure adequate micronutrient intake from such products because of the large variability in amount of product consumed, which can range ten-fold (e.g., 10-100 g dry flour/day).[36] A product formulated to provide the required amounts of nutrients in a daily ration of 30-40 g will provide insufficient micronutrients for infants who consume only 10 g/day, and may exceed Upper Levels among children who consume large quantities. Second, the daily ration of such products usually provides a relatively large amount of energy (e.g., 200 kcal/day), which may displace breastmilk. Third, over-reliance on a single food may reduce dietary diversity and limit intake of animal-source foods, fruits, and vegetables.

In part to overcome the above disadvantages of fortified blended foods, micronutrient powders and complementary food supplements have been developed.

Micronutrient powders (MNPs) are products that usually contain only vitamins and minerals for home fortification of traditional infant foods. Adding MNP to complementary foods just before a feeding ensures that the child receives a full daily dose of micronutrients with no nutrient losses due to cooking. Because MNPs usually contain little or no energy, they won't displace breastmilk or other foods, and the minimal list of ingredients and package weight make them less expensive than other options. The disadvantages of MNPs are that a) it is difficult to include all of the essential nutrients (especially

Type II nutrients such as potassium and phosphorus) without splitting the sachet into two portions per day, and b) they do not increase energy, fat or fatty acid, or protein content of the diet.

Complementary food supplements are defined as fortified food-based products to be added to other foods for home fortification or eaten alone to improve both macronutrient and micronutrient intake. Examples include small-quantity (e.g., 20 g/day) lipid-based nutrient supplements (LNS) and fortified full-fat soy flour (e.g., Ying Yang Bao[35, 37]). These products can provide essential fatty acids, powdered milk, micronutrients, macrominerals, and high-quality protein, depending on the formulation. As with MNPs, complementary food supplements provide the full intended dose of key nutrients regardless of the amount of staple food typically consumed, and there is no loss in nutrient content due to cooking. Because the energy content is relatively low, these products are unlikely to displace breastmilk. However, complementary food supplements are more expensive than MNPs, so it is important to evaluate whether the potential benefits of increased energy density, essential fatty acid content, and protein content of complementary foods are important in the target population.

Composition of products for home fortification

In recent years, significant progress has been made in evaluating the efficacy of home fortification and strategies for large-scale implementation.[38-40] There is clear evidence that the risk of iron-deficiency anemia can be greatly reduced by using MNPs or complementary food supplements for home fortification.[39, 41] To date, studies evaluating MNPs have shown little or no impact on linear growth of children under two years of age, whereas there is some evidence, though limited, for a positive growth impact of products that contain both micro- and macro-nutrients.[39] This has spawned debate and research on the optimal nutrient composition of products used for home fortification.

Macrominerals. One issue is which minerals to include in these products, and at what levels. Macrominerals such as calcium, phosphorus, and potassium are bulky and in some cases have a strong taste (e.g., potassium), which makes their addition to MNPs problematic and limits the quantity that is feasible to include in complementary food supplements. Because there are no good biomarkers of nutritional status for these nutrients, it is difficult to assess whether it is essential to include them in products for home fortification. Several of these nutrients are Type II nutrients required for deposition of lean body tissue and bone growth. Thus, depending on the local complementary food diet, there may be advantages to including them in fortified products.

Fat. Another issue is whether there are benefits to including fat in products for home fortification. International recommendations stipulate that infants and young children should consume > 30 percent of energy from fat.[42, 43] Breastmilk is normally an excellent source of fat, but as complementary foods are introduced and breastmilk intake declines, fat intake typically declines. For example, total fat intake of children in the Gambia declined from about 50 percent of energy to 25 percent of energy between birth and 18 months due to a decline in breastmilk intake, and declined further to about 15 percent of energy by 2-3 years of age.[44] In Bangladeshi children 24-35 months of age who were no longer receiving breastmilk, none met the recommended 30 percent of total energy from fat and 31 percent consumed < 10 percent of total energy from fat.[45] Thus, in some populations total fat intake is low during the period of complementary feeding.[42]

Poly-unsaturated fatty acids. The quality of fat included in such products is perhaps even more important. Poly-unsaturated fatty acids (PUFAs) are essential for brain development, immune function, and growth.[46-48] The long-chain PUFAs such as docosahexaenoic acid (DHA; 22:6n3) and arachidonic acid (20:4n6) are among the most important fatty acids in the brain, in particular for incorporation into synaptic membranes. DHA has a positive effect on neuronal proliferation and differentiation and decreases neuronal apoptosis (cell death). Most of the accretion of long-chain PUFAs into the brain occurs in the last trimester of gestation up to 2 years of age.[46] In low- and middle-income countries, the essential fatty acid content of complementary foods may be well below recommended levels.[42] For this reason, provision of a minimal quantity of essential fatty acids, particularly n-3 fats, via home fortification products could be beneficial.

The importance of fat for complementary feeding has been recognized for some time, but it is not always appreciated that there are risks associated with adding only fat to the complementary food diet, such as a few extra teaspoons of oil added to a child's meals each day. Fat has a high energy density (9 kcal/g), so when it is added to porridge, it will greatly increase energy density of the mixture. However, the mixture will then have a lower density of protein and micronutrients (amount per 100 kcal). If the child consumes the same amount of energy (assuming total energy intake is not limiting), he or she will receive lower amounts of protein and micronutrients from the mixture with fat added. For this reason, levels of all key nutrients should be increased when fat is added, to preserve or increase the micronutrient density of the foods.[49, 50]

One way to achieve this is to couple provision of micronutrients (e.g., MNP) with recommendations to include a good fat source in the child's diet such as vegetable oils that are adequate in essential fatty acids. Another way is to combine the fat source directly with the micronutrients needed, as in LNS. An advantage of this approach is that the high fat content of the product creates a stable food matrix that is resistant to spoilage because of low water activity. In addition, the food base helps to mask the taste of strong-tasting nutrients, and the fat content may enhance the absorption of fat-soluble vitamins.

Meeting nutrient gaps in complementary food diets using home fortification

Nutrient gaps in complementary feeding diets are often still evident even when educational strategies for improving dietary quality have been implemented. Several researchers have examined the potential of closing these gaps with fortified products. In Zimbabwe, Paul et al. found that provision of small-quantity LNS was able to close the nutrient gaps that remained after optimizing the use of locally available foods.[9] In Indonesia, the final complementary feeding recommendations developed by Santika et al.[10] required the inclusion of fortified products in addition to more than 3 servings/week of animal-source foods, of which 2 servings/week were chicken liver.

In the linear programming exercise used to assess various options for complementary feeding diets in Bangladesh, Ethiopia, and Viet Nam,[11] several scenarios using home fortification products (MNPs or small-quantity LNS) to help meet nutrient needs of 6-11-month-old infants were examined. When a home fortification product was included, the diets "chosen" by the program did not include any animal-source foods except for pork fat in Viet Nam, a cheap source of energy. This is because animal-source foods are generally expensive, and the linear programming analyses were set up to minimize cost. The other foods that appeared in these diets[11] were fat/oil or the local staple food because they are the lowest cost alternatives when micronutrient needs are being met by a fortified product. The dietary scenario that included unfortified foods from five food groups (including daily consumption of egg, plus fish or chicken), which did not meet needs for iron and zinc, cost 4-9 times more than the diets with MNPs and 1.4-3.3 times more than the diets that included small-quantity LNS. Thus, home fortification can ensure adequate micronutrient intake while minimizing cost.

However, it is important to emphasize that the "diets" that resulted from the linear programming analyses for the scenarios with MNPs or small-quantity LNS were lacking in dietary diversity, such as fruits and vegetables, because the program was designed to minimize cost. Adding purchased fruits and vegetables to diets that include the fortified products would increase their cost, though not as much as including animal-source foods in the quantities needed to meet micronutrient needs.

Issues to address for initiatives using fortified products for complementary feeding

Coupling the provision and/or marketing of fortified products with key educational messages on infant and young child feeding

Increasing access to fortified products for infant and young child feeding should not be a "stand-alone" intervention. Rather, it should be part of a package that includes key educational messages on breastfeeding and complementary feeding.[9] Ideally, those key messages would be communicated on the packaging and other materials that accompany fortified products, and reinforced through other communication channels.

Quinn et al., on behalf of the Maternal, Infant and Young Child Working Group of the Ten Year Strategy to Reduce Vitamin and Mineral Deficiencies, developed a working paper with specific recommendations for the marketing of fortified products for complementary feeding.[51] That guidance was designed to be consistent with the WHO Code of Marketing of Breast-milk Substitutes and to support optimal infant and young child feeding. "Best practice" recommendations in that document include labeling that states the importance of exclusive breastfeeding for the first six months and encourages continued breastfeeding up to two years or beyond. Other key messages for complementary feeding based on the Guiding Principles for Complementary

Feeding,[50] such as encouraging provision of nutrient-rich local foods and hygienic feeding practices, can be put directly on the packaging (depending on space limitations) or accompanying materials.

Research is needed to evaluate whether key messages coupled with increased access to fortified products can enhance the uptake of those messages and improve infant and young child feeding practices.

Appropriate marketing of fortified products for complementary feeding

The working paper by Quinn et al.[51] mentioned above provides guidance regarding the appropriate marketing of fortified products for complementary feeding. The issues addressed include product labeling, advertising and retail sales promotion to the general public and mothers outside of the health care system, the sale or use of fortified products within the healthcare system, provision of information on such products to health workers, and avoiding conflict of interest between companies that produce and distribute fortified products and government health authorities.

Sweet et al.[52] evaluated the extent to which the labeling of 160 current products for complementary feeding in South Africa met the product labeling recommendations in the working paper by Quinn et al.[51] None of the labels examined complied with all of the guidelines. About one-third of the labels did not provide an appropriate age of introduction of complementary foods, and about one-fourth used images of infants appearing younger than six months. Some of the labels suggested a daily ration too large for a breastfed child, which could interfere with breastmilk intake. Most of the labels provided instructions for safe and appropriate preparation/use and storage.

Similar evaluations of labels and marketing practices in other countries are needed, along with field-testing of the feasibility of the other guidelines on marketing proposed by Quinn et al.[51]

Monitoring composition and quality control of fortified products

In addition to guidelines on appropriate marketing of fortified products for complementary feeding, there is an urgent need for guidance on the recommended nutrient composition and quality control procedures for manufacturing of such products. The guidelines proposed by Quinn et al.[51] include mention of appropriate daily ration size, so as not to interfere with breastmilk intake, but otherwise do not address the desired macro- or micronutrient content of fortified products. An earlier document produced by the Formulation Subgroup of the Maternal, Infant and Young Child Working Group of the Ten Year Strategy to Reduce Vitamin and Mineral Deficiencies[35] reviews the formulations for fortified complementary foods and supplements that have been successful in improving the nutritional status of infants and young children. That paper provides targets for nutrient composition based on the empirical evidence, but is not a formal document with specifications to be used for monitoring at the national or global level. WHO recently released a statement on recommended composition of supplementary foods designed for the management of children with moderate acute malnutrition,[53] but the proposed nutrient composition is based on products providing ~70 percent of energy needs, which is far higher than would be desirable for fortified products for complementary feeding in the general population.

There is currently intense interest in developing better guidance for the composition of products used in complementary feeding. Recently, the Codex Alimentarius guidelines on formulated complementary foods for older infants and young children were revised.[54] Revisions were needed to reduce the recommended serving sizes to protect breastfeeding, expand the scope of complementary food beyond porridges to include small quantity LNS and other complementary food supplements, and make reference to improved processing techniques, updated vitamin and mineral references, essential fatty acids, and other important nutritional considerations that have emerged since these guidelines were created in 1991. In addition to policy guidelines such as Codex, evaluation of the nutritional adequacy and safety of fortified products currently being marketed in many countries is needed, as illustrated by the research done by Gibbs et al.[55]

Summary and Conclusions

There is growing recognition that infants and young children need complementary foods that have very high nutrient density. This is especially true at 6-12 months and particularly for iron and zinc. But the reality is that in low-income populations, infant diets are usually dominated by cereal-based porridges with low nutrient density. The phytate in grains and legumes compounds the problem by reducing absorption of iron, zinc, calcium, and phosphorus. Most complementary food diets will fall short in iron and zinc unless unrealistic amounts of animal-source foods are included daily.

Why is there such a gap in nutritional adequacy of diets for infants and young children? It is likely that shortfalls in certain key nutrients have been a characteristic of human diets since the agricultural revolution ~10,000 years ago. The pre-agricultural diet was apparently much higher in vitamins and minerals than modern diets. As a result, infants would probably have had much higher nutrient intakes than is true today and would have been able to meet their nutrient needs from the combination of breastmilk and premasticated foods provided by their mothers.[12]

Given this scenario, what are the possible solutions? Because infant diets in low-income countries are typically inadequate in several nutrients, a food-based approach is preferable to the provision of single-nutrient supplements. Increased intake of non-fortified but nutrient-rich foods, including under-utilized sources such as insects, may help meet nutrient needs. However, the evidence so far indicates that a gap may still remain for certain nutrients and diets where recommended amounts of animal-source foods are often prohibitively expensive for low-inome households. For this reason, strategies based on fortification of complementary foods have received considerable attention in recent years. This includes not only fortified blended foods but products for home fortification such as MNPs and products that include both macro- and micronutrients such as LNS. Each of these types of products has advantages and disadvantages, so the choice depends on the needs and desires of the target population. The optimal composition of products for home fortification is still under evaluation. Linear programming analyses indicate that nutrient needs can be met at a much lower cost by using home-fortification than with an unfortified diet, which would have to be very high in animal-source foods to approach nutritional adequacy.

If the use of fortified products for complementary feeding is scaled-up, several key issues need to be addressed. It is essential that programs promoting such products take steps to "bundle" them with key educational messages about infant and young child feeding that are consistent with the Guiding Principles for Complementary Feeding.[50] Marketing of fortified products for complementary feeding is a thorny issue, requiring careful attention to international and national guidelines, some of which are still under development. Authoritative guidance is also needed to facilitate adequate monitoring of the composition and quality control of fortified products for complementary feeding. Although these issues are challenging, finding workable solutions is vital to meeting the global health challenge of reducing malnutrition and promoting healthy growth in infants and young children worldwide.

Acknowledgments

Funding for this work was provided by the Bill & Melinda Gates Foundation to FHI 360 for the Alive & Thrive Project. We gratefully acknowledge the unpublished data provided by Christine Hotz and the HarvestPlus team, analyzed by Mary Arimond, and critical feedback on an earlier draft of the manuscript from Mary Arimond, Sandra Huffman, Luann Martin, Nancy Krebs and Christine Stewart.

References

1. thousanddays.org [Internet]. [cited October 29, 2012]; Available from: http://www.thousanddays.org/
2. Dewey KG, Brown KH. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. Food Nutr Bull. 2003 Mar;24:5-28.
3. WHO. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: World Health Organization; 1998.
4. Dewey KG, Huffman SL. Maternal, infant, and young child nutrition: combining efforts to maximize impacts on child growth and micronutrient status. Food Nutr Bull. 2009 Jun;30:S187-9.
5. Shrimpton R, Victora CG, de Onis M, Lima RC, Blossner M, Clugston G. Worldwide timing of growth faltering: implications for nutritional interventions. Pediatrics. 2001 May;107:E75.
6. Victora CG, de Onis M, Hallal PC, Blossner M, Shrimpton R. Worldwide timing of growth faltering: revisiting implications for interventions. Pediatrics. 2010 Mar;125:e473-80.
7. Dewey KG, Mayers DR. Early child growth: how do nutrition and infection interact? Matern Child Nutr. 2011 Oct;7 Suppl 3:129-42.
8. Vossenaar M, Solomons NW. The concept of "critical nutrient density" in complementary feeding: the demands on the "family foods" for the nutrient adequacy of young Guatemalan children with continued breastfeeding. Am J Clin Nutr. 2012 Apr;95:859-66.
9. Paul KH, Muti M, Chasekwa B, Mbuya MN, Madzima RC, Humphrey JH, Stoltzfus RJ. Complementary feeding messages that target cultural barriers enhance both the use of lipid-based nutrient supplements and underlying feeding practices to improve infant diets in rural Zimbabwe. Matern Child Nutr. 2012 Apr;8:225-38.
10. Santika O, Fahmida U, Ferguson EL. Development of food-based complementary feeding recommendations for 9- to 11-month-old peri-urban Indonesian infants using linear programming. J Nutr. 2009 Jan;139:135-41.
11. Vitta BS, Dewey KG. Identifying micronutrient gaps in the diets of breastfed 6-11 month old infants in Bangladesh, Ethiopia and Viet Nam using linear programming. Washington, D.C.: Alive & Thrive; 2012. http://www.aliveandthrive.org/resource/technical-paper-identifying-micronutrient-gaps-diets-breastfed-6-11-month-old-infants-bangl.
12. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. J Nutr. 2013, in J. Nutr. doi: 10.3945/jn.113.182527.
13. Georgieff MK. Long-term brain and behavioral consequences of early iron deficiency. Nutr Rev. Nov;69 Suppl 1:S43-8.
14. Lozoff B. Iron deficiency and child development. Food Nutr Bull. 2007 Dec;28:S560-71.
15. UNICEF. Improving child nutrition: The achievable imperative for global progress. New York: UNICEF; 2013.
16. Brown KH, Rivera JA, Bhutta Z, Gibson RS, King JC, Lonnerdal B, Ruel MT, Sandtrom B, Wasantwisut E, Hotz C. International Zinc Nutrition Consultative Group (IZiNCG) technical document #1. Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr Bull. 2004 Mar;25:S99-203.
17. Stoltzfus RJ. Iron interventions for women and children in low-income countries. J Nutr. 2011 Apr 1;141:756S-62S.
18. Kraemer K, Zimmermann MB, editors. Nutritional Anemia. Basel: Sight and Life Press; 2007.
19. Wessells KR, Brown KH. Estimating the global prevalence of zinc deficiency: results based on zinc availability in national food supplies and the prevalence of stunting. PLoS One.7:e50568.
20. West K, Klemm R, Sommer A. Vitamin A saves lives. Sound science, sound policy. [Commentary]. World Nutrition. 2010;1:211-29.
21. Golden MH. Proposed recommended nutrient densities for moderately malnourished children. Food Nutr Bull. 2009 Sep;30:S267-342.
22. Dewey KG, Adu-Afarwuah S. Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. Matern Child Nutr. 2008 Apr;4 Suppl 1:24-85.
23. Vazir S, Engle P, Balakrishna N, Griffiths PL, Johnson SL, Creed-Kanashiro H, Fernandez Rao S, Shroff MR, Bentley ME. Cluster-randomized trial on complementary and responsive feeding education to caregivers found improved dietary intake, growth and development among rural Indian toddlers. Matern Child Nutr. 2012 May 24;9:99-117.
24. Krebs NF, Westcott JE, Culbertson DL, Sian L, Miller LV, Hambidge KM. Comparison of complementary feeding strategies to meet zinc requirements of older breastfed infants. Am J Clin Nutr. 2012 Jul;96:30-5.
25. Gibson RS, Bailey KB, Gibbs M, Ferguson EL. A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. Food Nutr Bull. 2010 Jun;31:S134-46.
26. Krebs NF, Mazariegos M, Chomba E, Sami N, Pasha O, Tshefu A, Carlo WA, Goldenberg RL, Bose CL, et al. Randomized controlled trial of meat compared with multimicronutrient-fortified cereal in infants and toddlers with high stunting rates in diverse settings. Am J Clin Nutr. 2012 Oct;96:840-7.
27. Krebs NF, Mazariegos M, Tshefu A, Bose C, Sami N, Chomba E, Carlo W, Goco N, Kindem M, et al. Meat consumption is associated with less stunting among toddlers in four diverse low-income settings. Food Nutr Bull. 2011 Sep;32:185-91.
28. Krebs NF, Hambidge KM, Mazariegos M, Westcott J, Goco N, Wright LL, Koso-Thomas M, Tshefu A, Bose C, et al. Complementary feeding: a Global Network cluster randomized controlled trial. BMC Pediatr. 2011;11:4.
29. Kuyper EM, Vitta BS, Dewey KG. Novel and underused food sources of key nutrients for complementary feeding. Washington, D.C.: Alive & Thrive; 2013.
30. Kodondi KK, Leclercq M, Gaudin-Harding F. Vitamin estimations of three edible species of Attacidae caterpillars from Zaire. Int J Vitam Nutr Res. 1987;57:333-4.
31. Latham P, editor. Edible caterpillars and their food plants in Bas-Congo Province, Democratic Republic of Congo. Second ed: United Kingdom Department for International Development; 2005.
32. Kawarazuka N, Bene C. The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. Public Health Nutr. 2011 Nov;14:1927-38.
33. Ouedraogo HZ, Traore T, Zeba AN, Dramaix-Wilmet M, Hennart P, Donnen P. Effect of an improved local ingredient-based complementary food fortified or not with iron and selected multiple micronutrients on Hb concentration. Public Health Nutr. 2010 Nov;13:1923-30.
34. Pelto GH, Armar-Klemesu M. Balancing nurturance, cost and time: complementary feeding in Accra, Ghana. Matern Child Nutr. Oct;7 Suppl 3:66-81.
35. Ten Year Strategy to Reduce Vitamin and Mineral Deficiencies, Maternal, Infant, and Young Child Nutrition Working Group: Formulation Subgroup. Formulations for fortified complementary foods and supplements: review of successful products for improving the nutritional status of infants and young children. Food Nutr Bull. 2009 Jun;30:S239-55.

36. Dewey KG. Nutrient composition of fortified complementary foods: should age-specific micronutrient content and ration sizes be recommended? J Nutr. 2003 Sep;133:2950S-2S.
37. Sun J, Dai Y, Zhang S, Huang J, Yang Z, Huo J, Chen C. Implementation of a programme to market a complementary food supplement (Ying Yang Bao) and impacts on anaemia and feeding practices in Shanxi, China. Matern Child Nutr. 2011 Oct;7 Suppl 3:96-111.
38. Home Fortification Technical Advisory Group: hftag.gainhealth.org [Internet]. [cited October 29, 2012]; Available from: http://hftag.gainhealth.org/
39. Dewey KG, Yang Z, Boy E. Systematic review and meta-analysis of home fortification of complementary foods. Matern Child Nutr. 2009;5:283-321.
40. UNICEF-CDC. Global Assessment of Home Fortification Interventions. Geneva: Home Fortification Technical Advisory Group; 2013.
41. De-Regil LM, Suchdev PS, Vist GE, Walleser S, Pena-Rosas JP. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age. Cochrane Database Syst Rev. 2011:CD008959.
42. Michaelsen KF, Dewey KG, Perez-Exposito AB, Nurhasan M, Lauritzen L, Roos N. Food sources and intake of n-6 and n-3 fatty acids in low-income countries with emphasis on infants, young children (6-24 months), and pregnant and lactating women. Matern Child Nutr. 2011 Apr; 7 Suppl 2:124-40.
43. FAO. Fats and fatty acids in human nutrition: Report of an expert consultation. FAO Food and Nutrition Paper 91. Rome; 2010.
44. Prentice AM, Paul AA. Fat and energy needs of children in developing countries. Am J Clin Nutr. 2000 Nov;72:1253S-65S.
45. Yakes EA, Arsenault JE, Islam MM, Ahmed T, German JB, Drake C, Hossain MB, Lewis BL, Rahman AS, et al. Dietary intake of polyunsaturated fatty acids among breast-feeding and non-breast-feeding 24- to 48-month-old children in Bangladesh. J Pediatr Gastroenterol Nutr. 2011 Mar;52:351-9.
46. Lauritzen L, Carlson SE. Maternal fatty acid status during pregnancy and lactation and relation to newborn and infant status. Matern Child Nutr. 2011 Apr;7 Suppl 2:41-58.
47. Makrides M, Collins CT, Gibson RA. Impact of fatty acid status on growth and neurobehavioural development in humans. Matern Child Nutr. 2011 Apr;7 Suppl 2:80-8.
48. Prentice AM, van der Merwe L. Impact of fatty acid status on immune function of children in low-income countries. Matern Child Nutr. 2011 Apr;7 Suppl 2:89-98.
49. Briend A. Should we add oil to complementary foods for breastfed children in developing countries? J Pediatr Gastroenterol Nutr. 2005 Jul;41:12-3.
50. PAHO/WHO. Guiding principles for complementary feeding of the breastfed child. Washington, D.C.: Pan American Health Organization; 2003.
51. Quinn V, Zehner E, Schofield D, Guyon A, Huffman S. Using the Code of Marketing of Breast-milk Substitutes to Guide the Marketing of Complementary Foods to Protect Optimal Infant Feeding Practices; Produced under the Maternal Infant and Young Child Nutrition Working Group with assistance from the Global Alliance for Improved Nutrition (GAIN). Geneva, Switzerland; 2010.
52. Sweet L, Jerling J, Van Graan A. Field-testing of guidance on the appropriate labelling of processed complementary foods for infants and young children in South Africa. Matern Child Nutr. 2013;9 Suppl 1:12-34.
53. WHO. Technical note: Supplementary foods for the management of moderate acute malnutrition in infants and children 6-59 months of age. Geneva, Switzerland; 2012.
54. Codex Alimentarius Commission. Guidelines on formulated complementary foods for older infants and young children. CAC/GL 8-1991 revised 2013.
55. Gibbs M, Bailey KB, Lander RD, Fahmida U, Perlas L, Hess SY, Loechl CU, Winichagoon P, Gibson RS. The adequacy of micronutrient concentrations in manufactured complementary foods from low-income countries. Journal of Food Composition and Analysis. 2011;24:418-26.
56. Joint FAO/WHO Expert Consultation on Human Vitamin and Mineral Requirements, World Health Organization. Dept. of Nutrition for Health and Development. Vitamin and mineral requirements in human nutrition. 2nd ed. Geneva: World Health Organization; 2005.
57. National Research Council. Dietary reference intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: The National Academies Press; 2001.
58. Brown KH, Akhtar NA, Robertson AD, Ahmed MG. Lactational capacity of marginally nourished mothers: relationships between maternal nutritional status and quantity and proximate composition of milk. Pediatrics. 1986 Nov;78:909-19.
59. Krebs NF, Reidinger CJ, Hartley S, Robertson AD, Hambidge KM. Zinc supplementation during lactation: effects on maternal status and milk zinc concentrations. Am J Clin Nutr. 1995 May;61:1030-6.
60. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington, DC: The National Academies Press; 1997.
61. Joint FAO/WHO/UNU Expert Consultation. Human Energy Requirements. Rome; 2004.
62. Chaparro CM, Dewey KG. Use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings. Matern Child Nutr. 2010 Jan;6 Suppl 1:1-69.
63. Eaton SB, Eaton SB 3rd. Paleolithic vs. modern diets--selected pathophysiological implications. Eur J Nutr. 2000 Apr;39:67-70.
64. Eaton SB, Eaton SB 3rd, Konner MJ. Paleolithic nutrition revisited: a twelve-year retrospective on its nature and implications. Eur J Clin Nutr. 1997 Apr;51:207-16.

The Insight series of technical briefs addresses the continuum of care for good infant and young child feeding, from initiation of early and exclusive breastfeeding through complementary feeding in later infancy and the second year of life. Alive & Thrive aims to improve feeding practices during this critical period to save lives, prevent malnutrition, and promote optimal growth. Alive & Thrive is funded by the Bill & Melinda Gates Foundation and managed by FHI 360. Other members of the team include BRAC, GMMB, IFPRI, Save the Children, UC-Davis, and World Vision

For more information
visit our website:
www.aliveandthrive.org

alive&thrive
nourish. nurture. grow.

www.aliveandthrive.org

Headquarters Office
1825 Connecticut Avenue, NW
Washington, DC 20009
United States
Tel: (202) 884-8000
Fax: (202) 464-3966
Email: aliveandthrive@fhi360.org