



## The immediate consequences of early poor nutrition on children's health include an increased risk of morbidity and mortality from illness, and delayed mental and motor development

Ann Nutr Metab 2012;61(suppl 1):29–37

### Global Dietary Patterns and Diets in Childhood: Implications for Health Outcomes by Lindsay H. Allen

#### Key insights

Complementary feeding in developing countries is often restricted to cereals and legumes; however, it is important to add fruits, vegetables, and animal source foods to the diet to meet children's micronutrient needs. The inclusion of milk and dairy products or fish and meat in children's diets in developing countries is associated with faster growth, weight gain, and better cognitive performance.

#### Current knowledge

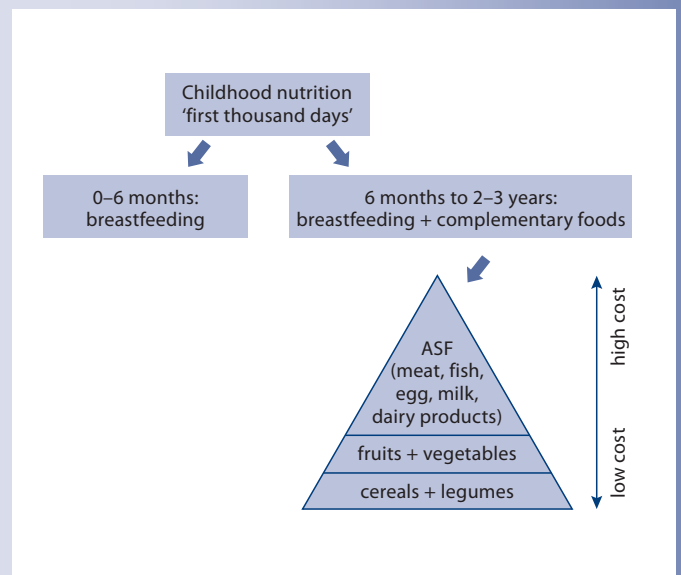
Since the 1970s, in order to prevent undernutrition and stunting, child feeding recommendations have been focusing on exclusive breastfeeding from birth to 6 months and introduction of high-quality complementary foods in addition to continued breastfeeding up to 2 years. Only in the late 1980s and early 1990s was growth stunting recognized as being caused by a lack of micronutrients in children's diets.

#### Practical implications

If families cannot afford including animal source foods in the diet, fortification with micronutrient powders or lipid-based supplements may be able to prevent micronutrient deficiencies.

#### Recommended reading

Dror DK, Allen LH: The importance of milk and other animal-source foods for children in low-income countries. *Food Nutr Bull* 2011;32:227–243.



Recommendations for children's diets from birth to 2–3 years. High cost frequently prevents families in developing countries from adding animal source foods (ASF) to their children's diets.

# Global Dietary Patterns and Diets in Childhood: Implications for Health Outcomes

Lindsay H. Allen

USDA, ARS Western Human Nutrition Research Center, University of California, Davis, Calif., USA

## Key Messages

- To grow and develop normally, exclusive breastfeeding is recommended for the first 6 months of life. After 6 months, breastfeeding should be continued for 2–3 years, but high-quality complementary foods should be added through age 2 years.
- It is difficult to meet children's micronutrient requirements after age 6 months unless their diet contains some animal source foods such as milk, eggs, fish or meat, and/or is fortified commercially or in the home. Typically, consumption of animal source foods or fortified foods is low, leading to a predictable and relatively universal set of nutrient deficiencies including vitamin A, iron, zinc, and vitamin B12.
- Adding animal source foods to the diets of children in developing countries has been demonstrated to improve their growth and development. Milk or dairy product intake is associated with child growth in both wealthier and poorer populations.

## Key Words

Breastfeeding • Children • Developing countries • Diets • Health • Infants • Micronutrients

## Abstract

This article provides an overview of child feeding recommendations and how these relate to actual practice and dietary adequacy, primarily in developing countries. From birth to 6 months, recommendations focus on optimal breastfeeding practices, although these are still suboptimal in about one third of infants in developing countries. From 6 months of age, breast milk can no longer meet all the nutrient requirements of the child, so from 6 months through at least 24 months, the recommendation is to continue breastfeeding but gradually introduce complementary foods. In poorer populations, the available foods for complementary feeding are primarily cereals and legumes, to which small amounts of fruits and vegetables are added, and even less animal source foods. Based on intake data from infants and preschoolers, it is evident that usual diets typically fall far short of supplying micronutrient needs. By adding more fruits, vegetables, and animal source foods the diet can be improved. Intervention studies show that increasing animal source food intake improves growth, muscle mass, and cognitive function of school children. Milk and dairy product intakes are correlated with greater child growth in many studies, even in industrialized countries. However, for many families, substantially improving children's diets by providing higher quality foods is often financially unrealistic. Newer approaches to home fortification of children's foods using

**KARGER**

E-Mail [karger@karger.com](mailto:karger@karger.com)  
[www.karger.com/anm](http://www.karger.com/anm)

© 2013 S. Karger AG, Basel  
0250-6807/12/0615-0029\$38.00/0

Lindsay H. Allen  
USDA, ARS Western Human Nutrition Research Center, University of California  
430 W. Health Sciences Drive  
Davis, CA 95616 (USA)  
E-Mail [Lindsay.allen@ars.usda.gov](mailto:Lindsay.allen@ars.usda.gov)

micronutrient powders or lipid-based nutrient supplements hold great potential to prevent micronutrient deficiencies at reasonable cost, thus preventing the adverse consequences of these deficiencies for child development.

Copyright © 2013 S. Karger AG, Basel

## Introduction

Child malnutrition remains a major global public health problem in spite of the advances that have been made in child feeding practices and medical care. This is due primarily to the fact that infants and children in many environments consume diets that are nutritionally inadequate, in that they do not provide adequate amounts of essential nutrients. Other factors are definitely involved, including poor maternal nutritional status in pregnancy and lactation, and frequent and chronic infections in the child; however, poor dietary patterns remain the central causal factor in child malnutrition.

Depending on the definition used, malnutrition affects about 50–150 million children under the age of 5 years, most of which live in Africa and Asia. UNICEF reports that poor nutrition causes one third of the under-5 year mortality [1]. The definition of ‘undernourished’ commonly refers to underweight and/or growth stunting which usually reflect chronic undernutrition and poor dietary quality. It also includes the less common condition of wasting, or low weight-for-length or weight-for-height, which is often caused by a more severe lack of food, and/or diarrhea or other diseases. Most growth stunting occurs during the first 2 years of life, the recognition of which has caused increased attention to the ‘first thousand days’ (i.e. nutrition during pregnancy and the first 2 years postpartum) as a critical period for improving child nutrition; recovery from stunting is difficult after this time [2].

Growth stunting was initially thought to be caused by an inadequate intake of protein, changing in the 1960s to the belief that the main cause was protein-energy malnutrition. In the 1970s, partly as a result of recommendations for protein intake being lowered, it became evident that protein deficiency was actually rather uncommon, occurring only where staple foods were low in protein or where there were food shortages, and could not explain

the global prevalence of stunting. The focus shifted to emphasizing the importance of exclusive breastfeeding for the first 4–6 months of life – which was later changed to the recommendation that it should be exclusive for the first 6 months of life – and improvements in the quality of complementary foods by mixing locally available sources of energy and protein, including legumes. In the late 1980s and early 1990s, the focus shifted again, recognizing that growth stunting in many countries was associated with poor-quality diets, meaning that their micronutrient density was low, i.e. plant-based diets with a low intake of animal source foods (ASF). Although it had been recognized for several decades that deficiencies of iron, vitamin A, zinc, iodine, and other micronutrients increased the risk of childhood illness and death and impaired child development, the scientific and public health community did not realize until the 1990s that the marginal micronutrient status caused by low-quality diets

could have adverse effects on growth, health, and function even in the absence of overt deficiency symptoms. Since that time, most of the focus on improving child nutrition has been on approaches to increase micronutrient intakes.

## Consequences for Health

The immediate consequences of early poor nutrition on children’s health include an increased risk of morbidity and mortality from illness, and delayed mental and motor development. In the longer term, early nutrient deficiencies and stunting are associated with many more subtle functional decrements including impaired intellectual performance in school children, increased risk of women delivering a low-birth-weight infant, and reduced adult work and earning capacity [3, 4]. While most attention is now being paid to improving nutrition in the first thousand days, the adequacy of dietary intake by preschoolers, schoolers, and adolescents remains important for their meeting their maximum growth potential, muscle mass, cognitive function and school performance, activity level and immune function [5].

***Most growth stunting occurs during the first 2 years of life, the recognition of which has caused increased attention to the ‘first thousand days’ (i.e. nutrition during pregnancy and the first 2 years postpartum) as a critical period for improving child nutrition.***

**Table 1.** Problems encountered with child feeding in developing countries [7]

Less than 50% are put to the breast within 1 h of birth
Only 36% are exclusively breastfed through age 6 months
Less than one third have met the minimum dietary diversity
Only 50% are fed the minimum number of meals
Coverage of interventions is generally low

**Table 2.** Nutrients that should be supplied by complementary foods [12]

Nutrient	%
Protein	35
Folate	5
Vitamin A	10–30
Zinc	40
Riboflavin	55
Calcium	60
Thiamin	70
Niacin (vitamin B3)	85
Vitamin B6	85
Iron	95

### Feeding during the First 6 Months of Life

The World Health Organization and other public health agencies recommend that infants be exclusively breastfed for the first 6 months of life [6], with breastfeeding initiated within the first hour of birth. While global awareness of the importance of breastfeeding has improved, unfortunately breastfed infants are often given other liquids and foods during the first 6 months of lactation. Exclusive breastfeeding is relatively uncommon; only 36% of infants from 46 developing countries are breastfed exclusively (table 1) [7]. The problem with feeding other liquids and foods during this period of life is that they usually have a lower density of energy and other nutrients than breast milk, and can be contaminated with bacteria. Breastfeeding is especially important during periods of illness because the infant will usually continue to consume breast milk when it rejects other foods.

To ensure optimal nutrient concentrations in breast milk, the mother needs to be well-nourished during lactation, and probably during pregnancy as well, since this

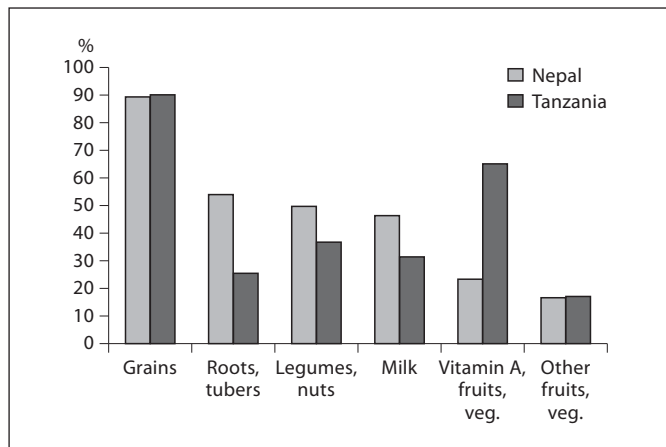
will enable her to begin lactation with good nutrient stores. The nutrients in breast milk most affected by low maternal intakes or status include all of the B vitamins, iodine, selenium, vitamin A, and vitamin D [8, 9]. Concentrations in milk have been reported to be as low as 6% (for iodine in regions of endemic iodine deficiency) and for many micronutrients, levels are usually about half of those in well-nourished women [9]. Where women's diets are lacking in these micronutrients, supplements need to be provided to the mother. To date, there has been no systematic analysis of the optimal amount of supplemental micronutrients needed to raise the concentration in milk of women consuming poor-quality diets to that of well-nourished women, but supplying at least the recommended daily intake would be a reasonable strategy.

### Complementary Feeding

Breastfeeding should continue until at least 24 months of age, but complementary foods should be introduced around age 6 months. These foods should be nutrient-dense due to the high nutrient requirements but small gastric capacity of young infants and children. They should be provided with sufficient frequency and correct consistency. It is important that the caretaker practices responsive feeding, i.e. is sensitive to cues indicating satiety and hunger, and uses appropriate techniques to encourage eating [10]. The degree of engagement in responsive feeding varies greatly across cultural settings, so caretaker education can improve infant feeding practices in many situations [11]. Introducing complementary foods before the age of 6 months does not improve growth and carries increased risk of microbiological infections and inadequate nutrient intakes.

***Introducing complementary foods before the age of 6 months does not improve growth, and carries increased risk of microbiological infections and inadequate nutrient intakes.***

After age 6 months, breast milk cannot provide the rapidly growing infant with sufficient amounts of some micronutrients, especially iron and zinc [6]. This is especially true for infants born with low birth weight or pre-term, as their nutrient stores (including iron) will be lower from the time of birth. From around 9 months to 2 years of age, complementary foods must supply approxi-



**Fig. 1.** Percent of Nepali and Tanzanian infants aged 9–11 months consuming food categories on the previous day (Demographic and Health Survey data). veg. = Vegetables.

mately the following percentages of the nutrients required by infants: protein 35, folate 5, vitamin A 10–30, zinc 40, riboflavin 55, calcium 60, thiamin 70, niacin and vitamin B6 85, and iron 95 [12] (table 2). For children with an average breast milk intake, complementary foods should provide daily an additional 200 kcal at 6–8 months of age, 300 kcal at 9–11 months, and 550 kcal at 12–23 months [12]. This requires feeding complementary food 2–3 times daily at age 6–8 months and 3–4 times after age 9 months, in addition to 1 or 2 snacks.

Examples of the type of foods provided between ages 9 and 11 months in Nepal and Tanzania are shown in fig. 1. Typically, as in these examples, the main complementary food in most developing countries is a porridge based on maize, rice, sorghum, millet or wheat. During cooking, such porridges become very gelatinous, so it is necessary to add a substantial amount of water to make the gruel edible for the child. This means that the nutrient density is often too low; energy content is often <0.5 kcal/g and the intakes of all other nutrients will be inadequate. The addition of fat can increase energy density and provide essential fatty acids if it is the right kind of oil (e.g. soy or canola), but adding too much fat results in lower food intake and a low density of other nutrients. Micronutrient-rich fruits and vegetables need to be added but often are not. However, without the addition of ASF it is not possible to meet the micronutrient needs of the child.

In a review of how well complementary foods meet the nutrient requirements of young children in developing countries, Brown et al. [13] calculated the nutrient intakes

of children aged 6–11 months in Guatemala, Bangladesh, and Malawi. Families were generally able to prepare complementary foods with sufficient energy density and feeding frequency such that infants' energy requirements were met, but in one third of families this was not achieved – often due to use of watery gruels and soups. Nevertheless, intakes of fat and protein were mostly adequate. In contrast, the intake of many micronutrients was inadequate to meet recommended intakes, notably B vitamins, calcium if the diet did not contain milk, iron, zinc, and in Bangladesh, vitamin A.

Such diets explain the high prevalence of micronutrient deficiencies in preschoolers in developing countries; around 50% have anemia, half of which is attributed to iron deficiency; one third are deficient in vitamin A, and 5–79% may be deficient in zinc based on estimates of absorbable dietary zinc and growth stunting. Vitamin B12 deficiency is also very common in infants and young children consuming diets low in ASF [14].

In countries such as the United States, infants and young children obtain most of their nutrients from breast milk and/or infant formulas, followed by cow's milk and fruit juices and fruit-flavored drinks [15]. Nutrient intakes are adequate for most except for a 'small but important' proportion of infants with low iron and zinc intakes. Fortified cereals and other fortified foods provide a substantial proportion of micronutrient requirements, especially vitamin A, folate, and iron. In fact, some concern has been voiced that there is an overreliance on fortified foods and some risk of excessive intakes of preformed iron, zinc, sodium, and folic acid, such that caretakers should be advised instead to provide a wide range of fruits, vegetables, and whole grains, good food sources of iron and fiber, and healthier sources of fat [15]. Overweight and obesity among children are becoming a major concern, and the diets of many exceed dietary guidelines for fat, cholesterol, added sugar, saturated fatty acids, and sodium, and are low in fiber [16]. The Nutrition Transition – the change from undernutrition to overnutrition – is happening in most countries in the world and the trend to children's higher intakes of sugar, salt, and saturated fat is occurring even in poor populations [17].

### Animal Source Foods

Where resources are limited, a higher proportion of dietary energy is consumed as low-cost cereals (e.g. rice, maize, wheat, sorghum) or root crops such as cassava. To these staples caretakers typically next add vegetables and legumes to the household meals, when affordable or

**Table 3.** Indicators of dietary diversity in children aged 6–24 months [22]

Food group
Starchy staples – grain, roots or tubers
Legumes and nuts
Dairy
Meat, poultry, fish, eggs
Vitamin A-rich fruits and vegetables
Other fruits and vegetables
Foods made with oil, butter or other fat

available in season, to increase dietary diversity. Then, when resources permit, smaller amounts of ASF are added. ASF are often unavailable due to factors such as cost which prohibits purchase by the household, and lack of refrigeration. In some populations, ASF are avoided for religious and/or cultural reasons. Unfortunately, the main factor determining dietary quality in most low-income populations is the proportion of daily energy intake that is consumed as ASF. This proportion varies from <5% in sub-Saharan Africa to 5–10% in other African countries and south Asia, 10–15% in eastern and north Asia, >20% in wealthier regions, and >30% in the United States. Specific examples show the percent of ASF energy consumed by toddlers as 1% for Bangladesh [Yakes, unpubl. data], 8% for Kenya [18], and 11% for Cambodia [19].

Compared to plant-based diets, ASF contain more preformed vitamin A (retinol), vitamins D and E, riboflavin, calcium, and iron and zinc in forms that are better absorbed from the diet [18, 20]. They are the only natural food source of vitamin B12, so in recent years it has become apparent that this vitamin deficiency is highly prevalent in population groups that consume low amounts of ASF, at all ages including infants and children [14]. Meat and dairy products differ in their content of micronutrients, with meat supplying more well-absorbed heme iron and zinc, and milk supplying more calcium, B12, riboflavin, and folate but little iron [18, 21].

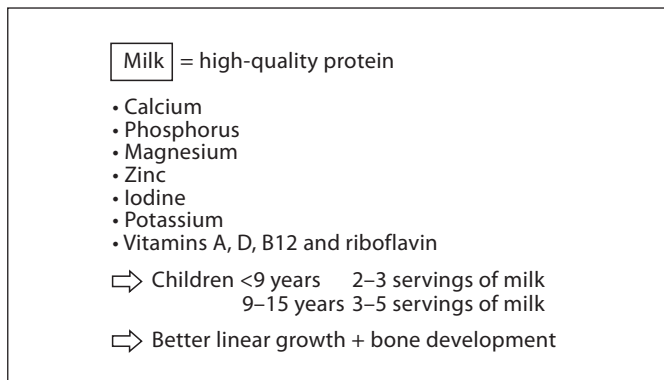
A diverse diet, with foods from all food groups, is necessary for population groups to meet their requirements for essential nutrients. Increasing dietary diversity is a specific recommendation for children 6 months to 2 years of age [10]. Dietary diversity (table 3) is a significant predictor of growth, as illustrated by an analysis of Demographic and Health Survey data from children aged 6–24 months in 11 countries in Africa and Latin America [22]. This relationship remained significant controlling for differences in children's age, maternal height, and body

mass index, the number of children <5 years in the household, and household health and welfare. Diversity was measured as the frequency of consumption of each food group. Illustrating the range of dietary diversity, a high proportion of children in Mali, Ethiopia, and Malawi consumed only 0–2 food groups on 3 or more days in the previous week, whereas over half of those in Peru and Colombia had consumed between 5 and 7 food groups on at least 3 days in the previous week. Among the food groups studied, milk intake was the strongest predictor of children's height. This is likely due to the growth-promoting effects of milk (see below), although it is also true that milk was more likely to be consumed by children than other ASF. One caveat about measuring dietary quality as a diversity score is that the amount of food consumed in each category is also important – a very small amount of a high-quality food will have little impact on nutritional status.

The importance of ASF in children's diets was also revealed by the Nutrition Collaborative Research Support Program (CRSP) conducted in Egypt, Kenya, and Mexico

***Compared to plant-based diets, ASF contain more preformed vitamin A (retinol), vitamins D and E, riboflavin, calcium, and iron and zinc in forms that are better absorbed from the diet.***

in the 1980s. The objective of the Nutrition CRSP was to determine the dietary causes of growth stunting and other malnutrition-related deficits in child development, pregnancy outcome, and work capacity, which at the time were generally assumed to be food shortage and specifically a lack of dietary energy [23]. However, in the Nutrition CRSP, which was a longitudinal observational study on infants, preschoolers, schoolers, and their mothers and fathers in each country, the investigators reported that energy intakes were usually adequate except in Kenya which suffered a drought and famine during the study. What was also clear was that within and across the countries, children who consumed a higher proportion of energy as ASF were taller, heavier, and had better cognitive and school performance than those with lower intakes. In addition, their birth weight was higher and correlated with the ASF intake of their mothers during pregnancy. Children had consistently better growth and other outcomes in Egypt, followed by Mexico, then Kenya, which corresponded with the Egyptians having the



**Fig. 2.** The importance of milk for childhood nutrition.

highest proportion of ASF, Mexicans intermediate, and Kenyans the lowest.

In Kenya, a follow-on randomized controlled trial subsequently confirmed the importance of ASF [5]. Based on the observations in the earlier Nutrition CRSP, the trial provided 554 school children with supplements of beef (60–80 g/day), milk (200–250 ml/day), or an equal amount of energy (250 kcal) as oil, added to one meal a day of the local maize, bean, and greens-based meal *githeri*. These meals were fed during the school term (about 6 months a year) for 2 years. A control group received no additional food, but their families were given a goat at the end of the study. Compared to the controls, the supplemental milk increased height gain by 15% in the more stunted children, mid arm muscle area by 50%, and mid upper arm circumference by 40%. Supplemental beef prevented loss in weight-for-height by 50%, and increased mid arm muscle area by 50% and mid upper arm circumference by 80%. The beef supplement significantly increased lean body mass, scores on cognitive tests, and end of term test scores, possibly due to its effects on activity and status of iron or other micronutrients.

The micronutrient status of the Kenyan children at baseline was very poor, reflecting the low consumption of ASF in the population [24]. Around two thirds of children had low serum zinc, 40% had low serum retinol, 30% were riboflavin deficient, and vitamin B12 deficiency was severe in 30% and marginal in 40%. The odds ratio for low serum vitamin B12 (<148 pmol/l) was 6.28 in children consuming the lowest versus highest tertile of ASF at baseline, even though intake of such foods was very low [25]. Only serum folate was normal in almost every child, a situation often found in developing countries. Iron status was uncertain due to the high prevalence of malaria.

Vitamin B12 status showed the greatest improvement, with the prevalence of severe deficiency falling from 20 to 40% in the control and energy-supplemented groups, and to 8 and 5% in the milk- and meat-supplemented children, respectively.

### The Importance of Milk for Infants and Children

The nutrients found in milk include those most often lacking in the diets of children in poorer regions of the world. It is a particularly important food for children, and for many it is a major source of calcium, phosphorus, magnesium, zinc, iodine, potassium, and vitamins A, D, B12 and riboflavin. It also provides high-quality protein. In wealthier countries, recommendations are usually that children under 9 years of age should consume 2–3 servings of milk per day, and those aged 9–15 years should consume 3–5 servings per day [26], although intake tends to decrease across childhood (fig. 2). Milk provides around 50% of children's calcium intake in the United States, with an additional 20% coming from dairy prod-

***A recent review of the importance of milk in the diets of children concluded that dairy product intake is associated with better linear growth and bone development during childhood, even in wealthier countries with a high usual intake of milk.***

ucts used as food ingredients. Consumption is not associated with an increased risk of overweight or obesity [26]. In recent years, evidence has accumulated to show that rickets in children in developing countries may be caused by either vitamin D or calcium deficiency, but often both conditions are involved, especially in Africa [27]. A recent review of the importance of milk in the diets of children concluded that dairy product intake is associated with better linear growth and bone development during childhood [26], even in wealthier countries with a high usual intake of milk [28]. Milk contains bioactive factors and stimulates insulin-like growth factor I and insulin synthesis, and peptides which can stimulate growth [29]. Milk is also a good vehicle for micronutrient fortification [26]. Adding milk powder to complementary foods improves the protein quality, allowing a reduction in total

**Table 4.** Indicators for assessing infant and young child feeding practices [37]

Early initiation of breastfeeding (within 1 h of birth)
Exclusive breastfeeding under 6 months
Continued breastfeeding between 12 and 15 months
Solid, semi-solid or soft foods received on the previous day, between 6 and 8 months
Received $\geq 4$ food groups on the previous day, between 6 and 23 months
Received the minimum number of servings of solid, semi-solid or soft foods on the previous day, between 6 and 23 months; minimum number changes by age across the period
Consumed iron-rich or iron-fortified foods (commercial or in the home) on the previous day

amount of protein, which could have potential metabolic advantages. It also allows for a reduced content of soy and cereal and thereby a reduction of potential antinutrients such as phytate. It is likely that adding milk could improve weight gain, linear growth, and recovery from malnutrition [28] and this is being tested in ongoing trials. Bioactive factors in whey might have beneficial effects on the immune system and muscle synthesis, but evidence from vulnerable groups is lacking. Milk proteins will improve flavor, which is important for acceptability in vulnerable groups. The most important disadvantage is a considerable increase in price. Adding 10–15% milk powder would double the price, which means that such a product should be used only in well-defined vulnerable groups with special needs.

### Family Foods versus Special Complementary Foods

After exclusive breastfeeding for the first 6 months of life, the World Health Organization advises that the infant can consume semi-solid, mashed or pureed foods. At 1 year of age, it is possible for the child to consume solid foods eaten by the rest of the family, which should include meat, fish, and eggs as often as possible. The suggestion has been made that young children in developing countries can be fed adequately with family foods, avoiding the

***At 1 year of age, it is possible for the child to consume solid foods eaten by the rest of the family, which should include meat, fish, and eggs as often as possible.***

need for specially prepared or processed complementary foods. To examine the feasibility of nourishing infants and young children with family foods, Vossenaar and Solomons [30] used data on the dietary patterns of Guatemalan adults with the best-quality diets. Based on previous estimates of breast milk intake throughout the first 2 years of life, in the Guatemalan community (where breastfeeding continues to be a major contributor to the nutrient intakes of infants and young children for several years), the authors assumed that breast milk supplied 75% of infants' total energy needs between 7 and 9 months, 50% between 10 and 12 months, and 40% between 13 and 24 months. Again, using a previously documented approach and assuming that milk composition was similar to that of well-nourished women, it was possible to calculate the 'gap' between what nutrients could be provided by breast milk and recommended nutrient intakes. Using this approach it was evident that if the children were fed the usual foods consumed in the best-fed households they would have inadequate intakes of calcium, iron, zinc, vitamin A, vitamin C, and folate. This conclusion is not surprising given the proportion of these nutrients that must come from complementary foods as discussed above, and the typical low ASF intake in this poor population.

### Strategies for Improving the Diets of Infants and Young Children

In addition to receiving one (e.g. high-dose vitamin A supplements which are provided routinely 2 or 3 times a year through 5 years of age in many developing countries, or iron) or more (e.g. multiple micronutrient supplements formulated for children) micronutrients as supplements, the following strategies are used to improve micronutrient intake through foods.

#### *Increasing Dietary Diversity and the Intake of ASF*

A generally recognized and encouraged approach to filling the nutrient gap for infants and young children is to increase their intake of ASF, fruits, and vegetables. This is, of course, not always feasible due to cost, availability, and cultural constraints. Using a linear programming technique and estimating the micronutrient gaps in the intakes of breastfed infants 6–8 and 9–11 months of age in Bangladesh, Ethiopia, and Vietnam, investigators concluded that unfortified foods could meet nutrient re-



quirements [31]. However, this would require an unrealistically high intake of liver and a level of intake of other ASF which greatly increased the cost of the diet. Nevertheless, many women do not understand the importance of these foods in the diet of their child and can be educated to include eggs, dairy products or fruits and vegetables in their usual diet. There is currently considerable ongoing research into how to increase the intake of nutrient-dense fruits and vegetables and ASF through improved agricultural practices, and especially those of small-holders.

Infants and young children are too often given sugary snacks or foods, which provide energy but lack other essential nutrients. In Cambodia, Demographic and Health Survey data reveal that around half of the children had consumed a sugary food on the previous day. Snacks supplied 42% of the total energy intake of Cambodian children aged 12–24 months [19], and rice an additional 20%. In KwaZulu-Natal, sugar was consumed by infants aged 6–12 months at least 4 times a week by 50%, savory snacks by 42%, biscuits by 27%, carbonated drinks by 12%, and sweets by 8% [32].

#### *Increasing Micronutrient Intake through Fortified, Processed Complementary Foods*

There are many types of fortified commercial complementary foods on the market, worldwide. However, consumption of such fortified ‘baby foods’ is quite low in many poorer populations. From the Demographic and Health Survey for infants aged 9–11 months it is estimated that these are consumed by 3–4% in Cambodia and Malawi, 5–6% in Tanzania and Burkina Faso, and 12–15% in Nepal and Senegal [Huffman, in preparation]. The nutrient content and quality of these foods can vary widely depending on the manufacturer and the price of the food, and there is concern that marketing strategies may encourage their use at too early an age and/or that they may displace breast milk. Not surprisingly, they are perceived as convenient by caretakers [33].

#### *Increasing Micronutrient Intake through Micronutrient Supplements*

Home-prepared foods for infants and children can be fortified by the caretaker using specially formulated micronutrient powders [34] or supplements delivered by programs or purchased by the household. Lipid-based nutrient supplements (LNS) are a relatively new approach

### ***Infants and young children are too often given sugary snacks or foods, which provide energy but lack other essential nutrients.***

for delivering multiple micronutrients. These supplements usually have a peanut base (although other nuts can be used), with added sugar and dry milk, and are high in lipid (energy) and essential fatty acids. They can be consumed as such but are often mixed into complementary foods. The composition and dose can be varied so the products are suitable for young infants as well as pregnant and lactating women. LNS were developed initially as a source of energy and other nutrients for treating severely malnourished children [35]. Now, interest has increased in their use to prevent micronutrient deficiencies, growth stunting, and associated developmental delays in young children [36]. Several trials are underway to compare the efficacy of LNS versus micronutrients alone delivered in tablet or powdered form.

#### **Summary Measures to Assess Infant and Young Child Feeding Status**

Knowledge of the most important dietary influences on the nutritional status of the infant and young child, described above, has enabled the development of indicators of the success of infant and young child feeding (table 4) [37]. While these are intended for evaluation of success in population groups, they can also be useful for clinicians assessing individual mother-child dyads.

#### **Disclosure Statement**

The author currently receives funding from the Bill and Melinda Gates Foundation as an investigator in studies of the efficacy of LNS. In the past, she has been funded by the Small Livestock CRSP (USAID) to evaluate the effects of ASF on nutritional status.

#### **References**

- 1 UNICEF: The State of the World's Children. New York, 2012.
- 2 Martorell R, Khan LK, Schroeder DG: Reversibility of stunting: epidemiological findings in children from developing countries. *Eur J Clin Nutr* 1994;48(suppl 1):S45–S57.
- 3 Mendez MA, Adair LS: Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. *J Nutr* 1999;129:1555–1562.
- 4 Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, Sachdev HS: Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 2008; 371:340.

- 5 Neumann CG, Bwibo NO, Murphy SP, Sigman M, Whaley S, Allen LH, Guthrie D, Weiss RE, Demment MW: Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. *J Nutr* 2003; 133:3941S–3949S.
- 6 WHO: The Optimal Duration of Exclusive Breastfeeding. Report of an Expert Consultation. Geneva, World Health Organization, 2001.
- 7 Lutter CK, Daelmans BM, de Onis M, Kothari MT, Ruel MT, Arimond M, Deitchler M, Dewey KG, Blossner M, Borghi E: Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. *Pediatrics* 2011;128:e1418–e1427.
- 8 Allen LH: B vitamins in breast milk: relative importance of maternal status and intake, and effects on infant status and function. *Adv Nutr* 2012;3:362–369.
- 9 Allen LH, Graham J: Assuring micronutrient adequacy in the diets of young infants; in Delange FM, West KPJ (eds): *Micronutrient Deficiencies in the First Months of Life*. Basel, Karger, 2003, pp 55–88.
- 10 PAHO: *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington, DC, PAHO, 2003.
- 11 Penny ME, Creed-Kanashiro HM, Robert RC, Narro MR, Caulfield LE, Black RE: Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: a cluster-randomised controlled trial. *Lancet* 2005; 365:1863–1872.
- 12 WHO/UNICEF, Brown K, Allen L, Dewey K (eds): *Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge*. Geneva, World Health Organization, 1998.
- 13 Brown K, Pearson J, Kimmons J, Hotz C: Options for achieving adequate intake from home-prepared complementary foods in low-income countries; in Black R, Michaelsen KF (eds): *Public Health Issues in Infant and Child Nutrition*. Nestle Nutrition Workshop Series, Pediatric Program. Philadelphia, Vevey, Lippincott Williams & Wilkins, 2002.
- 14 Allen LH: How common is vitamin B-12 deficiency? *Am J Clin Nutr* 2009;89:693S–696S.
- 15 Fox MK, Reidy K, Novak T, Ziegler P: Sources of energy and nutrients in the diets of infants and toddlers. *J Am Diet Assoc* 2006; 106:S28–S42.
- 16 Wilson TA, Adolph AL, Butte NF: Nutrient adequacy and diet quality in non-overweight and overweight Hispanic children of low socioeconomic status: the Viva la Familia Study. *J Am Diet Assoc* 2009;109:1012–1021.
- 17 Popkin BM, Adair LS, Ng SW: Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev* 2012;70: 3–21.
- 18 Murphy SP, Gewa C, Liang LJ, Grillenberger M, Bwibo NO, Neumann CG: School snacks containing animal source foods improve dietary quality for children in rural Kenya. *J Nutr* 2003;133:3950S–3956S.
- 19 Anderson VP, Cornwall J, Jack S, Gibson RS: Intakes from non-breastmilk foods for stunted toddlers living in poor urban villages of Phnom Penh, Cambodia, are inadequate. *Matern Child Nutr* 2008;4:146–159.
- 20 Murphy SP, Allen LH: Nutritional importance of animal source foods. *J Nutr* 2003; 133:3932S–3935S.
- 21 Allen LH, Dror DK: Effects of animal source foods, with emphasis on milk, in the diet of children in low-income countries. *Nestle Nutr Workshop Ser Pediatr Program* 2011; 67:113–130.
- 22 Arimond M, Ruel MT: Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *J Nutr* 2004;134:2579–2585.
- 23 Allen LH: The nutrition CRSP: what is marginal malnutrition, and does it affect human function? *Nutr Rev* 1993;51:255–267.
- 24 Siekmann JH, Allen LH, Bwibo NO, Demment MW, Murphy SP, Neumann CG: Kenyan school children have multiple micronutrient deficiencies, but increased plasma vitamin B-12 is the only detectable micronutrient response to meat or milk supplementation. *J Nutr* 2003;133:3972S–3980S.
- 25 McLean ED, Allen LH, Neumann CG, Pearson JM, Siekmann JH, Murphy SP, Bwibo NO, Demment MW: Low plasma vitamin B-12 in Kenyan school children is highly prevalent and improved by supplemental animal source foods. *J Nutr* 2007;137:676–682.
- 26 Dror DK, Allen LH: The importance of milk and other animal-source foods for children in low-income countries. *Food Nutr Bull* 2011;32:227–243.
- 27 Pettifor JM: Vitamin D and/or calcium deficiency rickets in infants and children: a global perspective. *Indian J Med Res* 2008;127: 245–249.
- 28 Hoppe C, Andersen GS, Jacobsen S, Molgaard C, Friis H, Sangild PT, Michaelsen KF: The use of whey or skimmed milk powder in fortified blended foods for vulnerable groups. *J Nutr* 2008;138:145S–161S.
- 29 Molgaard C, Larnkjaer A, Arnberg K, Michaelsen KF: Milk and growth in children: effects of whey and casein. *Nestle Nutr Workshop Ser Pediatr Program* 2011;67:67–78.
- 30 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;95:859–866.
- 31 Binetti V, Dewey K: Identifying Micronutrient Gaps in the Diets of Breastfed 6- to 11-Month Old Infants in Bangladesh, Ethiopia and Viet Nam Using Linear Programming. Washington, DC, Alive & Thrive, 2012.
- 32 Faber M, Spinnler Benade A: Breastfeeding, complementary feeding and nutritional status of 6–12 month old infants in rural Kwa-Zulu Natal. *S Afr J Clin Nutr* 2007;20.
- 33 Peltó GH, Armar-Klemesu M: Balancing nurturance, cost and time: complementary feeding in Accra, Ghana. *Matern Child Nutr* 2011;7(suppl 3):66–81.
- 34 Christofides A, Asante KP, Schauer C, Sharieff W, Owusu-Agyei S, Zlotkin S: Multi-micronutrient Sprinkles including a low dose of iron provided as microencapsulated ferrous fumarate improves haematologic indices in anaemic children: a randomized clinical trial. *Matern Child Nutr* 2006;2: 169–180.
- 35 Ciliberto MA, Sandige H, Ndekha MJ, Ashorn P, Briend A, Ciliberto HM, Manary MJ: Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: a controlled, clinical effectiveness trial. *Am J Clin Nutr* 2005;81:864–870.
- 36 Phuka JC, Maleta K, Thakwalakwa C, Cheung YB, Briend A, Manary MJ, Ashorn P: Postintervention growth of Malawian children who received 12-mo dietary complementation with a lipid-based nutrient supplement or maize-soy flour. *Am J Clin Nutr* 2009;89:382–390.
- 37 Daelmans B, Dewey K, Arimond M: New and updated indicators for assessing infant and young child feeding. *Food Nutr Bull* 2009;30:S256–S262.