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Special Issue Based on a World Health Organization Expert Consultation on Complementary Feeding

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The Food and Nutrition Bulletin encourages letters to the editor regarding issues dealt with in its contents.

Foreword

The importance of nutrition as a foundation for healthy development is underestimated. Poor nutrition leads to ill health, and ill health causes further deterioration in nutritional status. These effects are most dramatically observed in infants and young children, who bear the brunt of the onset of malnutrition and suffer the highest risk of disability and death associated with it. In 2001, 50% to 70% of the burden of diarrheal dieseases, measles, malaria, and lower respiratory infections was attributable to malnutrition.

But the children who die represent only a small part of the total health burden due to nutritional deficiencies. Maternal malnutrition and inappropriate breastfeeding and complementary feeding represent huge risks to the health and development of those children who survive. Deficiencies in the diet of vitamin A, iodine, iron, and zinc are still widespread and are a common cause of excess morbidity and mortality, particularly among young children. Over 50 million children are wasted, and in low-income countries one in every three children is stunted by the age of five years. Indeed, many children never reach this age. The effects of poor nutrition and stunting continue over the child's life, contributing to poor school performance, reduced productivity, and other measures of impaired intellectual and social development.

Inappropriate feeding practices are a major cause of the onset of malnutrition in young children. Children who are not breastfed appropriately have repeated infections, grow less well, and are almost six times more likely to die by the age of one month than children who receive at least some breastmilk. From the age of six months onwards, when breastmilk alone is no longer sufficient to meet all nutritional requirements, infants enter a particularly vulnerable period of complementary feeding, during which they make a gradual transition to eating ordinary family foods. The incidence of malnutrition rises sharply during the period from 6 to 18 months of age in most countries, and the deficits acquired at this age are difficult to compensate for later in childhood.

During the past decade, there has been considerable progress in the implementation of interventions to improve breastfeeding practices. Clear recommendations and guidelines, combined with political commitment and increased allocation of resources, have enabled many governments to establish programs that combine the necessary actions to protect, promote, and support breastfeeding. Consequently, a steady improvement in breastfeeding practices, as demonstrated by increased rates of exclusive breastfeeding, has been observed in various countries.

However, similar progress has not made been in the area of complementary feeding. While research and development have contributed to an expanding evidence base for making recommendations on appropriate feeding and developing effective interventions for children more than six months of age, translation of new knowledge into action has lagged behind.

To address this gap, the World Health Organization (WHO) convened a global consultation on complementary feeding (Geneva, 9 to 13 December 2001), which brought together over 60 experts from a variety of disciplines and agencies. As a background for discussion, WHO commissioned five papers, which examined the current state of knowledge concerning:

» Energy and nutrient requirements of infants and young children, and the relative requirements of complementary foods to meet these needs at various ages;
» Caregiver behaviors influencing infant and young child feeding;
» Household-level technologies to improve the availability of safe and adequate complementary foods;
» Macrolevel approaches to improve the availability of adequate complementary foods;
» Lessons learned from the implementation of programs to improve breastfeeding practices.

The consultation was asked to review and update recommendations for appropriate complementary feeding and to identify actions needed to accelerate programmatic efforts, including priorities for

research and development of tools for planning and implementation of interventions. The participants discussed issues relating to foods and feeding, and considered the intricate links between maternal nutrition and appropriate breastfeeding and complementary feeding practices.

This special issue of the *Food and Nutrition Bulletin* presents the background papers and proceedings of the consultation; it is meant to help guide policymakers and program planners at all levels in taking appropriate action to give effect to the Global Strategy for Infant and Young Child Feeding,* which the World Health Assembly adopted in May 2002. It is hoped that the results will motivate all concerned parties to make the investments required to ensure that the nutritional needs of infants and young children are met worldwide.

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* WHA55/2002/REC/1, Annex 2 and http://www.who.int/gb/EB_WHA/PDF/WHA55/ea5515.pdf.

Acknowledgments

Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs

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Abstract

This paper provides an update to the 1998 WHO/ UNICEF report on complementary feeding. New research findings are generally consistent with the guidelines in that report, but the adoption of new energy and micronutrient requirements for infants and young children will result in lower recommendations regarding minimum meal frequency and energy density of complementary foods, and will alter the list of "problem nutrients." Without fortification, the densities of iron, zinc, and vitamin B_6 in complementary foods are often inadequate, and the intake of other nutrients may also be low in some populations. Strategies for obtaining the needed amounts of problem nutrients, as well as optimizing breastmilk intake when other foods are added to the diet, are discussed. The impact of complementary feeding interventions on child growth has been variable, which calls attention to the need for more comprehensive programs. A six-step approach to planning, implementing, and evaluating such programs is recommended.

Key words: Infant nutrition, micronutrients, energy density, meal frequency, feeding practices, nutrition education

Introduction

In 1998, the World Health Organization (WHO) and UNICEF jointly published a document entitled "Complementary feeding of young children in developing countries: a review of current scientific knowledge" [1].

The objectives of this document were to provide the background information needed for the development of scientifically sound feeding recommendations and the design of intervention programs to optimize the dietary intake of children and thereby enhance their nutritional status and general health. Since the publication of that document, a number of countries have initiated or expanded programs to promote optimal child feeding practices. WHO convened a consultation in December 2001 to review the experiences of these programs and determine which programmatic activities are most likely to promote improved complementary feeding. This paper was prepared to review selected information and major conclusions of the 1998 document prior to this recent consultation and to indicate, as appropriate, any specific areas where new information may necessitate reconsideration of the earlier conclusions. This paper focuses primarily on the two major sections of the 1998 publication that dealt with energy and nutrient requirements from complementary foods. It also provides information on the interactions between complementary feeding and breastmilk intake and discusses several relevant programmatic issues, including the impact of complementary feeding programs on children's growth and key components of successful complementary feeding programs.

The 1998 document used a simple, consistent conceptual framework to establish energy and nutrient requirements from complementary foods, based on the difference between young children's estimated total energy and nutrient requirements and the amounts of energy and nutrients transferred in breastmilk to children of different ages. As part of the present exercise, updated reports on these energy and nutrient requirements were considered, and new information was sought on the composition and amounts of breastmilk transferred from mother to child in relation to the child's postnatal age.

Energy required from complementary foods and factors affecting intake of these foods

Basis for the 1998 estimates of energy needs from complementary food

As indicated above, the amount of energy required from complementary foods was estimated as the difference in age-specific recommendations for the total energy intake and the amount of energy transferred in breastmilk to children at different ages. Because of age-related differences in the two factors that determine the energy needs from complementary foods, data were presented separately for the age groups of 6 to 8, 9 to 11, and 12 to 23 months. The minimum age considered was based on the recommendation that complementary foods should be introduced at six months, and the upper age limit was due to the limited amount of information on the quantity of energy transferred in breastmilk to children older than two years (although this amount was assumed to be a relatively small proportion of an older child's total energy intake).

The WHO/UNICEF 1998 document [1] relied on recommendations for energy intake that were first presented by the International Dietary Energy Consultative Group (IDECG) in 1994. IDECG considered separate estimates of the average energy needs of infants [2] and of children aged 12 to 23 months [3], both of which were derived from measurements of total daily energy expenditure, using the doubly-labeled water method, and estimates of the energy contents of fat and protein deposited during growth. Assumptions regarding fat and protein accrual were based on the WHO/National Center for Health Statistics (NCHS) growth curves and other published data on the components of weight gain. The IDECG recommendations were approximately 9% to 39% less than the earlier Food and Agriculture Organization (FAO)/WHO/United Nations University (UNU) recommendations [4], which were based on observed dietary intakes of healthy infants and children, plus 5% in infants to compensate for an assumed underestimation of their intakes. The WHO/UNICEF complementary feeding document accepted the IDECG recommendations rather than the earlier FAO/WHO/UNU recommendations, because the observed intakes do not necessarily reflect desirable intakes, so the estimates based on measurements of energy expenditure and growth were deemed to be more appropriate.

New information on energy requirements

Since the publication of the WHO/UNICEF 1998 document on complementary feeding, more information has become available on young children's energy requirements, and FAO/WHO/UNU have been conducting a formal review of this information prior to its planned publication of revised estimates. The new FAO/WHO/UNU recommendations for energy intake during infancy will be based on the longitudinal measurements of total energy expenditure and body mass and composition that were obtained from 76 US children at 3, 6, 9, 12, 18, and 24 months of age [5]. The FAO/WHO/UNU recommendations for children aged 1 to 18 years will be based on a regression line fitted to energy expenditures by children of different ages, using information drawn from multiple data sets collected by different investigators. However, the vast majority of the data for one-year-old children were derived from the same longitudinal study of US children noted above, so it would seem to be more appropriate to use this information directly rather than the data from the regression equation, which is influenced by data from children in other age groups. Thus, for the current analyses of energy requirements from complementary foods, the estimates of total energy requirements are based entirely on the data from the US longitudinal study.

In this data set, energy requirements differed by the child's age, feeding practice (breastfed or nonbreastfed), and sex. Because very little of the available information on breastmilk energy intake is presented according to the child's sex, the data on energy requirements were examined for both sexes combined in the current review. Notably, the energy requirements of breastfed infants aged 6 to 23 months were approximately 4% to 5% less than those of nonbreastfed infants, and only the requirements of breastfed children are considered here. The proposed new FAO/WHO/UNU estimates, shown in the tables below, differ slightly from the data in the original published report from the longitudinal studies, because the actual energy expenditures per unit of body weight were multiplied by the reference median weights of an international reference for breastfed infants [6] rather than the weights of the children in the study sample.

To facilitate comparison of information from the 1998 publication and the recent US data, the means of the new US data at 6 and 9 months, 9 and 12 months, and 12, 18, and 24 months were used for the periods 6 to 8 months, 9 to 11 months, and 12 to 23 months, respectively. Table 1 presents the figures used for energy requirements in the WHO/UNICEF 1998 publication and the updated values. The new estimates are about 5% to 18% less than those used in the 1998 publication when requirements are expressed per day, and about 5% to 13% less when requirements are expressed in relation to body weight. Part of this difference can be explained by the fact that the IDECG analyses included some data from undernourished children, whose energy requirements may have been elevated. Thus, the newer figures may be more appropriate estimates of the energy needs of healthy, breastfed children. On the other hand, the fact that the newer estimates were based only on US children leaves some uncertainty about possible geographic differences in

energy requirements, and inclusion of more data from other populations would be worthwhile.

New information on energy transferred in breastmilk

We were able to locate only one newly published study on breastmilk intake and energy content of milk from mothers in a low-income country [7]. This study, in which mothers were given either a high- or a low-energy supplement, provided data for only one of the relevant age periods, namely, infants about six months of age, approximately 76% of whom were exclusively breastfed. The mean amount of milk consumed (764 g/day) and the mean energy density of the milk (0.74 kcal/g or 0.308 MJ/100 g) were well within the ranges reported for exclusively breastfed infants in the WHO/UNICEF 1998 publication (776 ± 141 g/day and 0.67 ± 0.16 kcal/g or 0.280 ± 0.067 MJ/100g, respectively). Thus, there does not seem to be sufficient new information to justify any revisions of the previously published estimates of breastmilk energy intakes.

Impact of new information on estimates of young children's energy requirements from complementary foods

Table 2 provides the estimates of the amount of energy required from complementary foods, using either the theoretical total energy requirements suggested by IDECG in 1994 or the newly proposed requirements derived from the US longitudinal data. The figures based on the recently revised estimates of total energy requirements are approximately 25% to 32% less than those published in 1998.

Appropriate feeding frequency and energy density of complementary foods

The WHO/UNICEF 1998 document recognized that recommendations on the frequency of feeding complementary foods depend on the energy density of these foods. By the same token, guidelines on the appropriate energy density of complementary foods must be con-

TABLE 1. Energy requirements according to age group, as presented in the WHO/UNICEF 1998 publication [1] and in recent longitudinal studies of US children [5]

Age group (mo)	WHO/UNICEF 1998	US longitudinal data	WHO/UNICEF 1998	US longitudinal data
	kcal/day		kcal/kg body weight/day	
6–8	682	615	83	77.0
9–11	830	686	89	77.5
12–23	1,092	894	86	81.3
	MJ/day		MJ/kg body weight/day	
6–8	2.85	2.57	0.36	0.32
9–11	3.47	2.87	0.37	0.32
12–23	4.57	3.74	0.36	0.34

TABLE 2. Energy requirements from complementary foods according to age group, based on total energy requirements proposed by IDECG (as presented in the WHO/UNICEF 1998 publication [1]) or on total energy requirements reported in a recent publication of longitudinal studies of US children [5]

| Age group (mo) | Total energy requirements | | Milk energy intake | Energy required from complementary foods | |
	WHO/UNICEF 1998	US longitudinal data		WHO/UNICEF 1998	US longitudinal data
	kcal/day				
6–8	682	615	413	269	202
9–11	830	686	379	451	307
12–23	1,092	894	346	746	548
	MJ/day				
6–8	2.85	2.57	1.73	1.12	0.84
9–11	3.47	2.87	1.59	1.88	1.28
12–23	4.57	3.74	1.45	3.12	2.29

sidered in relation to the number of meals consumed. Because very little empirical information was available at the time of that publication on the effects of feeding frequency and energy density on total daily energy intake and energy intake from breastmilk, theoretical estimates were developed for the minimum energy density that would be acceptable, considering different feeding frequencies and limited information regarding the so-called functional gastric capacity of children of different ages. Briefly, the amount of energy required from complementary foods was divided by the number of meals providing these foods and by an assumed gastric capacity of 30 g/kg body weight per day to estimate the minimum appropriate energy density for that number of meals. For these analyses, the energy requirements from complementary foods were based on age-specific total daily energy requirements plus 2

SD (to meet the needs of almost all children) minus the amount of energy provided by breastmilk.

Since the 1998 publication, no new studies have been published with empirical data on these relationships in breastfed children. Therefore, it is still necessary to rely on theoretical calculations, and these analyses have been updated to reflect the newly revised estimates of total daily energy requirements. Table 3 provides revised summary information for adequately nourished children receiving low (mean –2SD), average, or high (mean +2SD) amounts of breastmilk energy. Because of the reduction in the estimated total energy requirements, the minimum energy density calculated to be sufficient to allow children to satisfy their total energy needs is less for any particular number of meals than was suggested previously. As shown in table 4 for well-nourished children consuming average amounts of

TABLE 3. Minimum dietary energy density required to attain the level of energy needed from complementary foods in one to five meals per day, according to age group and level (low, average, or high) of breastmilk energy intake (BME)[a]

	6–8 mo			9–11 mo			12–23 mo		
Energy	Low BME	Average BME	High BME	Low BME	Average BME	High BME	Low BME	Average BME	High BME
Total energy required + 2SD (kcal/day)[b]	769	769	769	858	858	858	1,118	1,118	1,118
BME (kcal/day)	217	413	609	157	379	601	90	346	602
Energy required from complementary foods (kcal/day)	552	356	160	701	479	257	1,028	772	516
Minimum energy density (kcal/g)									
1 meal/day	2.22	1.43	0.64	2.46	1.68	0.90	2.98	2.24	1.50
2 meals/day	1.11	0.71	0.32	1.23	0.84	0.45	1.49	1.12	0.75
3 meals/day	0.74	0.48	0.21	0.82	0.56	0.30	0.99	0.75	0.50
4 meals/day	0.56	0.36	0.16	0.61	0.42	0.23	0.74	0.56	0.37
5 meals/day	0.44	0.29	0.13	0.49	0.34	0.18	0.60	0.45	0.30

a. Assumed functional gastric capacity (30 g/kg reference body weight) is 249 g/meal at 6–8 months, 285 g/meal at 9–11 months, and 345 g/meal at 12–23 months.
b. Total energy requirement is based on new US longitudinal data averages plus 25% (2SD).

TABLE 4. Minimum dietary energy density required to attain the level of energy needed from complementary foods taken in two to five meals per day by children with an average level of breastmilk energy intake, based on estimated total energy requirements proposed by IDECG (as presented in the WHO/UNICEF 1998 publication [1]) or on the estimated total energy requirements reported in a recent publication of longitudinal studies of US children [4][a]

	6–8 mo		9–11 mo		12–23 mo	
Meals/day	WHO/ UNICEF 1998	US longitudinal data	WHO/ UNICEF 1998	US longitudinal data	WHO/ UNICEF 1998	US longitudinal data
2	0.88	0.71	1.16	0.84	1.48	1.12
3	0.59	0.48	0.77	0.56	0.98	0.75
4	0.44	0.36	0.58	0.42	0.74	0.56
5	0.35	0.29	0.46	0.34	0.59	0.45

a. Analysis based on average breastmilk intake. Assumed functional gastric capacity (30 g/kg reference body weight) is 249 g/meal at 6–8 months, 285 g/meal at 9–11 months, and 345 g/meal at 12–23 months.

breastmilk, for example, the estimates of the minimum energy density range from 19% to 28% less than those presented in the WHO/UNICEF 1998 publication.

Because of the newly proposed decrease in estimated total energy requirements and the consequent reduction in the minimum energy density of complementary foods that is needed to ensure adequate intake from a particular number of meals, it may be possible to achieve sufficient energy density while delivering fewer meals per day. To develop feeding guidelines for the general population, we used data based on children with a low energy intake from breastmilk, since these provide the most conservative assumptions regarding the minimum desirable energy density or number of meals. As shown in table 5, when most households are able to prepare meals with a minimum energy density of 1.0 kcal/g, children in all age groups should be able to consume enough energy if they receive at least three meals per day. When most households are able to prepare foods with a minimum energy density of only 0.80 kcal/g, children from 6 to 11 months of age would be able to satisfy their energy needs from complementary foods if they received at least three meals per day, whereas those from 12 to 23 months of age would need to receive at least four meals per day.

TABLE 5. Minimum daily number of meals required to attain the level of energy needed from complementary foods with mean energy density of 0.6, 0.8, or 1.0 kcal/g for children with low level of breastmilk energy intake, according to age group[a]

Energy den-sity (kcal/g)	No. of meals		
	6–8 mo	9–11 mo	12–23 mo
0.6	3.7	4.1	5.0
0.8	2.8	3.1	3.7
1.0	2.2	2.5	3.0

a. Estimated total energy requirement is based on new US longitudinal data averages plus 25% (2SD). Assumed functional gastric capacity (30 g/kg reference body weight) is 249 g/meal at 6–8 months, 285 g/meal at 9–11 months, and 345 g/meal at 12–23 months.

Lipid content of complementary foods

The nutritional importance of the lipid content of the whole diet in general, and of complementary foods in particular, was described in the WHO/UNICEF 1998 publication [1]. The specific contributions of dietary lipids include their supply of essential fatty acids and fat-soluble vitamins and their enhancement of dietary energy density and sensory qualities. In general, as the breastmilk energy intake declines as a proportion of total dietary energy, the total lipid intake also subsides, because breastmilk is a relatively more abundant source of lipids than most complementary foods. The 1998 publication provided calculations regarding the amounts of lipids that should be present in complementary foods to assure that lipids provide 30% to 45% of the total dietary energy from both breastmilk and other foods [1]. This range of dietary lipid was felt to represent a reasonable compromise between the risks of too little intake (and possible adverse affects on dietary energy density and essential fatty acid consumption) and excessive intake (possibly increasing the likelihood of childhood obesity and future cardiovascular disease, although evidence in support of these latter concerns is limited [8]). This originally proposed range of lipid intake still represents a general consensus of other experts who have considered this topic more recently [9], although several authors have emphasized the need for more research on optimal lipid intakes and on the minimum levels of essential fatty acid intakes that are appropriate in early childhood [10, 11].

Because of the revised figures for total energy requirements, we recalculated the percentage of energy in complementary foods that should be provided by lipids to maintain the total lipid intake from the whole diet at a level that is 30% to 45% of total energy. As shown in table 6, the revised energy requirements have little impact on the estimates of the percentage of energy from complementary foods that should be provided as lipid, except for infants aged 9 to 11 months.

TABLE 6. Percentage of energy from complementary foods that should be provided as lipid to prepare diets with 30% or 45% of total energy as lipid, according to age group and to two sources (WHO/UNICEF [1] and US longitudinal data [4]) for total energy requirements[a]

% of total dietary energy as lipid	Level of breastmilk energy intake	6–8 mo		9–11 mo		12–23 mo	
		WHO/UNICEF 1998	US longitu-dinal data	WHO/UNICEF 1998	US longitu-dinal data	WHO/UNICEF 1998	US longitu-dinal data
30	Low	21	19	25	24	28	28
30	Medium	0	0	13	5	21	17
30	High	0	0	0	0	5	0
45	Low	43	42	44	43	45	44
45	Medium	37	34	41	38	43	42
45	High	1	0	31	7	38	34

a. Assumes well-nourished mothers with breastmilk lipid concentrations of 38 g/L and breastmilk energy density of 0.68 kcal/g.

In this age group, the new estimates of total energy requirements suggest that considerably less lipid energy than previously recommended is needed from complementary foods either when children receive an average amount of energy from breastmilk and it is considered desirable for them to obtain 30% of their total energy as lipid, or when they receive a high amount of energy from breastmilk and it is considered desirable for them to obtain 45% of their total energy as lipid.

Factors affecting intake of complementary foods

A number of independent factors, such as the child's appetite, the caregiver's feeding behaviors, and the characteristics of the diets themselves, may influence the amounts of complementary foods that are consumed. We were unable to locate new studies on child appetite or the treatment of anorexia, so this remains an important topic for future research; issues of child feeding behaviors were reviewed in another background paper prepared for the consultation. Although one new study did propose that frequent feeding of breastmilk and water may interfere with the intake of other foods, this hypothesis was not formally tested [12]. New studies that were identified concerning the effects of energy density, viscosity, and other sensory properties of the diet on the total amounts consumed are described below.

Several recently published studies provided information on the effects of dietary energy density and/or viscosity on the consumption of complementary foods. A study of 30 children aged 6 to 23 months in rural South Africa compared meal intakes when either a local maize-milk porridge (with an energy density of about 0.6 to 1.1 kcal/g) or a similar porridge fortified with α-amylase and additional cereal (with an energy density of about 1.0 to 1.3 kcal/g) was served [13]. Both types of porridge had a similar low viscosity. Overall, children ingested about 6% less of the porridge with greater energy density, but they consumed about 24% more energy at a meal from this enhanced preparation.

Another study was designed to compare the intakes of local food mixtures that were formulated to contain one of two levels of energy density (either about 1.1 kcal/g or about 0.6 kcal/g) and either high or low viscosity [14]. The research was conducted in 18 fully weaned Peruvian children, aged 8 to 17 months, who were hospitalized while recovering from malnutrition or infection. Reduction in dietary viscosity was achieved by adding α-amylase, and other sensory properties of the diet were held constant by using specific additives. The children ate substantially greater amounts of the low-energy-density diets, but they consumed significantly more total energy from the high-energy-density, low-viscosity diet.

Vieu et al. [12] studied the effects of the energy density and sweetness of complementary foods on intakes by 24 breastfed West African infants aged 6 to 10 months. Three modified semiliquid gruels were prepared from the same foods as typical local gruels, but the modified gruels contained amylase and had a lower water content, so that they had a higher energy density than the unmodified gruel (about 1.09 kcal/g vs. 0.45 kcal/g), while maintaining similar viscosity. The proportions of millet and sucrose were also varied in the three modified gruels to achieve progressively increasing levels of sweetness, while keeping the energy density constant. Although the children consumed greater amounts of the unmodified than of the modified gruels, the energy intakes from the preparations with greater energy density increased by about 40% (not including breastmilk). The intakes of the higher-density gruels also increased progressively in relation to the level of sweetness of the preparations.

The results of all three of these foregoing studies are consistent in several respects. First of all, the energy density of complementary foods is clearly a major determinant of the amount of food that is consumed. When other aspects of the diet are similar, children consume more of a low-energy-density diet, presumably in an attempt to meet their energy needs. Nevertheless, the energy intake from complementary foods varies directly with their energy density, despite the lower intakes of the foods with greater energy density. These conclusions are consistent with the findings of the WHO/UNICEF 1998 document. The new evidence suggesting that increased sweetness of a locally prepared porridge may stimulate greater intake [12] must be balanced against the possible risks of excessive sugar intake, such as displacement of more nutrient-rich foods and promotion of dental caries. The sweetest preparation in this study provided nearly 20% of energy as sucrose, an amount that is about twice as much as one current recommendation [15].

Only one of the studies cited above was designed to examine the effects of energy density and viscosity independently, while controlling for other sensory properties of the diet [14]. This study clearly demonstrated that reduction of the viscosity of very thick preparations boosted the energy intakes of nonbreastfed children. The 1998 document noted that earlier research on this question produced inconsistent results, possibly because of inadequate study designs. The addition of this new study adds greater credence to the likelihood that a reduction in viscosity of high-energy-density complementary foods will augment young children's energy intakes from complementary foods. However, because none of the intervention studies with breastfed children have included 24-hour measurements of breastmilk intake, it is not yet known whether this increased intake from complementary foods would result in a net increase in total daily energy intake.

Duration of need for special transitional foods

The WHO/UNICEF 1998 document [1] explored the question of how long specially formulated foods are needed for young children because of their particular physiological limitations and nutritional needs. Of major concern was the ability of children of different ages to chew and swallow food of different physical forms successfully, especially foods of thick or solid consistency. The only information available at that time on the percentage of children consuming more than trivial amounts (≥ 5 g/day) of solid foods was drawn from a longitudinal study of Peruvian infants. The percentage of infants receiving solid foods increased progressively during the first year; by 11 months of age, 72% of the Peruvian infants were consuming these foods.

A new set of relevant information has been published from the DONALD study [16]. Consumption of commercial infant food products and other foods by 293 mostly upper-economic-class infants was measured at 3, 6, 9, and 12 months of age in Dortmund, Germany, during the period from 1990 to 1996. Foods were categorized as breastmilk, commercial infant foods (infant formula, cereals, and baby foods), or other (home-prepared infant food, family table food, and cow's milk). Although the physical characteristics of the foods were not described, it can be assumed that the commercial infant foods were generally of liquid or semisolid consistency when served, whereas at least some of the family foods were of more solid consistency. The percentages of total food intake provided by each of these food categories were analyzed by age, for breastfed and nonbreastfed infants combined (table 7). The percentage of total food intake that was provided by commercial infant foods peaked at 6 months and declined to 37% by 12 months. By contrast, the percentage of total food intake provided by other foods increased progressively during the first year, reaching 62% of the total by 12 months. Unfortunately, no information was presented on the proportion of children who were receiving these other foods at each age.

We also reviewed information collected during the US Department of Agriculture (USDA) Continuing Survey of Food Intake by Individuals (CSFII) for the period 1994–96 and 1998 [17]. Information from children less than two years of age was analyzed to determine the percentage of children who received different types of foods and the amounts consumed. The foods were categorized as infant formula, other fluid milk, infant juice, infant cereal, other infant foods (strained, junior, or toddler jarred foods, including meat, vegetables, fruits, desserts), and other foods. Although specific information was not available on the consistency of these foods, the same assumptions that were applied to the DONALD survey can be used to interpret the CSFII data. Because no information was obtained during the CSFII survey on the amount of breastmilk intake, the data were disaggregated according to breastfeeding status, and the information is presented only for breastfed children. Only about 50% of the US children were breastfed during the first two months of life, and the rate of breastfeeding declined progressively to about 12% to 14% by the end of the first year. Infants first began receiving other foods (possibly including some solid foods) during the third month, although the mean amounts consumed did not exceed 5% of nonbreastmilk energy intake until the infants were more than five months of age (table 8). By 9 to 11 months of age, almost all (94%) of the children who were still receiving breastmilk were also receiving these other foods, which provided more than 50% of their total nonbreastmilk energy intakes during months 9 to 11 and approximately 80% of these intakes in the second year.

In summary, the results of these two newer surveys seem consistent with the earlier conclusion that most infants are physically able to consume home-available family foods in substantial amounts during the second year of life, probably by about 12 months of age. Thus, special foods with liquid or semisolid consistency may be required only during the period from 6 to 11 months.

Of related interest, the associations between the age of introduction of "lumpy" solid foods and the types of foods consumed and the presence of feeding prob-

TABLE 7. Food intake by breastfed German infants, according to type of food and age[a]

| Age (mo) | No. of infants | Total food intake (g/day) | Breast-milk | Commercial infant food (CIF) | | | | Other |
				Infant formula	Cereal	Baby food	All CIF	
3	118	805 ± 144	47	47	2	2	51	2
6	153	906 ± 161	25	33	10	19	62	13
9	180	1,034 ± 207	4	20	13	20	53	43
12	229	1,070 ± 239	1	13	9	15	37	62

a. Data from ref. 16. Analysis includes both breastfed and nonbreastfed infants.

lems at 6 and 15 months of age were studied among nearly 10,000 English children [18]. Children who first received lumpy foods after 10 months of age were more likely to have feeding difficulties at 15 months than those who were introduced to these foods between 6 and 9 months of age. Although these results are intriguing and suggest that there may be a critical window for introducing lumpy solid foods, the study design does not exclude the possibility of reverse causality. Thus, prospective trials of the timing of introduction of lumpy foods would be of value.

Protein and micronutrients required from complementary foods

Calculations of the amounts of nutrients needed from complementary foods

In the WHO/UNICEF 1998 report [1], the amounts of protein and micronutrients needed from complementary foods were estimated by subtracting the amounts provided by human milk from the recommended nutrient intakes (RNIs) for each of the age intervals (6 to 8, 9 to 11, and 12 to 23 months). These were then converted into desired nutrient densities (per 100 kcal of complementary food) by dividing by the amount of energy needed from complementary foods at each age. The RNIs used in 1998 were based primarily on the Dietary Reference Values from the United Kingdom Department of Health [19], except for energy, protein, folate, iron, and zinc. The RNIs for protein were taken from a 1996 IDECG report [2, 3, 20], those for folate and iron were based on FAO/WHO estimates [21], and those for zinc were derived from calculations from

metabolic studies (Annex III of the 1998 report [1]).

Since the 1998 report was completed, new dietary reference intakes (DRIs) have been published by the US Institute of Medicine for many of the micronutrients [22–25]. It is worthwhile to consider how the new DRIs would influence the estimates of nutrients needed from complementary foods. However, before doing so, it is important to understand the various methods used to derive DRIs for children under two years of age. For most nutrients, the data are lacking to establish the estimated average requirement (EAR) in this age range. This makes it difficult to calculate the recommended dietary allowance (RDA), which is usually defined as the EAR plus two standard deviations. Therefore, several different approaches have been utilized. One is to estimate the RDA based on extrapolation from values for adults or older children. Another is to estimate an adequate intake (AI), based on mean observed intakes of healthy individuals. For children aged zero to six months, the AI values used for the new DRIs were calculated from intakes of exclusively breastfed infants. For the age interval from 7 to 12 months, the estimated intake from human milk (assuming a mean volume of 600 ml/day) was added to the amounts expected to come from complementary foods (based on observed intakes of solid foods in the US population at this age). Because AI values are based on observed intakes, they are dependent on the dietary practices of the reference population. With respect to the "true" nutrient needs of children under two years of age, the AI may be an overestimate (if the diet of the reference population has generous amounts of the nutrient), or an underestimate (if the observed intakes are marginal but do not result in obvious clinical symptoms). Whenever possible, the DRI committees attempted to reconcile

TABLE 8. Food energy intake by breastfed US children, according to type of food and age[a]

				% of nonbreastmilk energy					
Age (mo)	No. of children	No. (%) of breastfed children	Total non-breastmilk energy (kcal/day)	Infant formula	Other milk	Juice	Cereal	Other infant food	Other food
< 1	93	45 (48)	92.5	99.8	0	0	0	0	0.1
1	117	60 (51)	96.0	98.8	0	0.5	0.2	0	0.6
2	140	53 (38)	118.0	95.3	0	0.1	2.4	1.9	0.3
3	149	48 (32)	142.6	85.8	0	2.8	5.2	5.4	0.8
4	151	38 (25)	193.5	69.3	0	1.6	20.0	4.9	4.3
5	139	38 (27)	268.6	55.0	3.1	2.8	8.6	16.4	13.8
6	124	35 (28)	313.3	41.0	0	3.0	16.1	25.2	14.7
7	128	31 (24)	373.0	33.2	1.4	2.7	17.1	24.0	21.7
8	130	28 (22)	496.6	32.7	2.9	5.1	13.0	16.3	29.9
9	141	17 (12)	451.8	19.0	3.3	3.9	6.6	13.9	53.2
10	123	16 (13)	495.8	16.9	2.0	2.3	8.8	15.9	54.1
11	116	16 (14)	704.8	9.4	8.6	3.8	2.1	2.2	74.0
12–23	1,084	68 (6)	825.6	0.8	14.7	1.1	1.2	2.2	80.1

a. Data from ref. 17 (available on CD-ROM).

the AI values with values based on extrapolation of the RDA for other age groups, but this was not always an option.

Because of the lack of data for children under 12 months of age, the DRIs in this age interval were based primarily on AI values, except for iron and zinc. For children aged 12 to 23 months, most of the DRIs were based on RDAs extrapolated from other age groups. As a result, there are some inconsistencies between the DRIs for children 7 to 12 and 12 to 23 months of age. For example, the DRIs for vitamins A and C are considerably higher at 7 to 12 months than at 12 to 23 months (500 vs. 300 µg for vitamin A; 50 vs. 15 mg for vitamin C), even though the requirements are presumably proportional to body size, and the DRIs for folate, calcium, and phosphorus nearly double

between the age intervals from 7 to 12 months and from 12 to 23 months (from 80 to 150 µg for folate, from 270 to 500 mg for calcium, and from 275 to 460 mg for phosphorus).

In addition to the new DRIs, the revised vitamin and mineral requirements are being published by WHO/FAO [26]. Table 9 compares the RNI values used in the WHO/UNICEF 1998 complementary feeding report with both the new DRIs and the new WHO/FAO requirements. For some nutrients (folate, niacin, pantothenic acid, riboflavin, thiamine, vitamin B$_6$, vitamin B$_{12}$, and vitamin D), the WHO/FAO values are identical or nearly identical to the new DRIs in all three age intervals. For others, the new WHO/FAO values are closer to the RNIs used in the 1998 report (vitamin A, vitamin C, vitamin K, and selenium), or

TABLE 9. Comparison of recommended nutrient intakes used in the WHO/UNICEF 1998 Report [1] with the new dietary reference intakes (DRI) [22–25] and WHO 2002 values [26][a]

Nutrient	Recommended nutrient intake								
	6–8 mo			9–11 mo			12–23 mo		
	WHO/ UNICEF 1998	New DRI	WHO 2002	WHO/ UNICEF 1998	New DRI	WHO 2002	WHO/ UNICEF 1998	New DRI	WHO 2002
Protein (g/day)	9.1	NA	NA	9.6	NA	NA	10.9	NA	NA
Vitamin A (µg RE/day)	350	500[b]	400	350	500[b]	400	400	300	400
Folate (µg/day)	32	80[b]	80	32	80[b]	80	50	150	160
Niacin (mg/day)	4	4[b]	4	5	4[b]	4	8	6	6
Pantothenic acid (mg/day)	1.7[c]	1.8[b]	1.8	1.7[c]	1.8[b]	1.8	1.7[c]	2.0[b]	2.0
Riboflavin (mg/day)	0.4	0.4[b]	0.4	0.4	0.4[b]	0.4	0.6	0.5	0.5
Thiamine (mg/day)	0.2	0.3[b]	0.3	0.3	0.3[b]	0.3	0.5	0.5	0.5
Vitamin B$_6$ (mg/day)	0.3	0.3[b]	0.3	0.4	0.3[b]	0.3	0.7	0.5	0.5
Vitamin B$_{12}$ (µg/day)	0.4	0.5[b]	0.5	0.4	0.5[b]	0.5	0.5	0.9	0.9
Vitamin C (mg/day)	25	50[b]	30	25	50[b]	30	30	15	30
Vitamin D (µg/day)	7	5[b]	5	7	5[b]	5	7	5[b]	5
Vitamin K (µg/day)	10[c]	2.5[b]	10	10[c]	2.5[b]	10	10[c]	30[b]	15
Calcium (mg/day)	525	270[b]	400	525	270[b]	400	350	500[b]	500
Chloride (mg/day)	500	NA	NA	500	NA	NA	800	NA	NA
Copper (mg/day)	0.3	0.2[b]	NA	0.3	0.2[b]	NA	0.4	0.3	NA
Fluoride (µg/day)	0.05[c]	0.5[b]	NA	0.05[c]	0.5[b]	NA	0.05[c]	0.7[b]	NA
Iodine (µg/day)	21	130[b]	90	21	130[b]	90	12	90	90
Iron (mg/day)[d]	11	11	9.3	11	11	9.3	6	7	5.8
Magnesium (mg/day)	75	75[b]	54	80	75[b]	54	85	80	60
Manganese (mg/day)	0.02[c]	0.6[b]	NA	0.02[c]	0.6[b]	NA	0.02[c]	1.2[b]	NA
Phosphorus (mg/day)	400	275[b]	NA	400	275[b]	NA	270	460	NA
Potassium (mg/day)	700	NA	NA	700	NA	NA	800	NA	NA
Selenium (µg/day)	10	20[b]	10	10	20[b]	10	15	20	17
Sodium (mg/day)	320	NA	NA	350	NA	NA	500	NA	NA
Zinc (mg/day)	2.8[e]	3	4.1[f]	2.8[e]	3	4.1[f]	2.8[e]	3	4.1[f]

a. Shaded areas are cases in which at least two of the reference values differ by more than 20%. NA, Not yet available.
b. Based on adequate intake (AI) estimates.
c. Based on "safe nutrient intake" from British dietary reference values.
d. Assuming medium bioavailability (10%).
e. Based on Annex III of the 1998 report.
f. Assuming moderate bioavailability (30%).

differ from both the new DRIs and the previously used RNIs in some or all of the three age intervals (calcium, iodine, iron, magnesium, and zinc).

The differences in RNIs for a given nutrient are due primarily to the methods used for estimating the requirements. For example, most of the RNI values chosen for the 1998 report were based on clinical studies or factorial estimates, rather than the AI approach. The rows highlighted in table 9 indicate the nutrients for which the difference between any two of the three RNIs listed in each age interval was greater than 20%. In some cases, use of the new DRIs or WHO/FAO values would not cause a major change in the likelihood that a nutrient would be identified as a "problem nutrient" during the period of complementary feeding, because the usual intakes in developing countries are either considerably greater than or considerably less than the desired nutrient level, regardless of the reference used. In others, however, using the new estimates would significantly alter the conclusions reached in the 1998 report with regard to problem nutrients. For this purpose, it is not clear which set of RNIs would be most appropriate, given the limitations of the AI approach described above. For example, if one used the new DRIs, vitamin C would be flagged as a "problem nutrient" at 6 to 11 months in some developing countries, because the DRI (based on the AI approach) is relatively high (50 mg) due to the generous amounts of vitamin C in solid foods consumed in the United States. In the 1998 report, vitamin C was not identified as a problem nutrient, because the UK dietary reference value (based on clinical studies) is only 25 mg, an amount that can be satisfied by breastmilk intake alone (assuming an average breastmilk intake). On the other hand, the new DRI for calcium at 7 to 12 months (270 mg, based on an AI) is about half of the UK dietary reference value chosen for the 1998 report (525 mg), which would make it less likely that calcium would be flagged as a problem nutrient at this age (the opposite is true at 12 to 23 months). Because there are no simple biochemical markers of calcium status, it is not clear whether US breastfed infants are consuming adequate calcium at 7 to 12 months, and thus whether the AI approach is valid. Therefore, given the current state of knowledge, it is not a simple task to decide which RNI to choose for each nutrient.

Identifying the problem nutrients

As described in the 1998 report [1], "problem nutrients" are those for which there is the greatest discrepancy between their content in complementary foods and the estimated amount required by the child. They can be identified by comparing the estimates of desirable nutrient density of complementary foods (amount of nutrient per 100 kcal) with the actual densities of the nutrients in the foods consumed by breastfed children in various populations.

At the time the 1998 report was prepared, these comparisons were available for only two data sets (Peru and the United States) for the age ranges of 6 to 8 and 9 to 11 months, and only one data set (Mexico) for the age range of 12 to 23 months. Tables 10 and 11 provide these comparisons for a somewhat larger group of data sets: five countries are represented at 6 to 8 and 9 to 11 months (Bangladesh, Ghana, Guatemala, Peru, and the United States), and three at 12 to 23 months (Guatemala, Mexico, and the United States). In the first three columns, the tables show the average desired nutrient densities (i.e., assuming an average breastmilk intake) of selected nutrients based on three different sets of RNIs: the values used in the 1998 report, the new DRIs, and the new WHO/FAO requirements. For the densities based on the latter two references, the newer estimates of energy requirements, described above, were utilized to calculate the desired nutrient density. (Because the newer energy requirement estimates are lower than those used in the 1998 report, all of the desired nutrient densities will be somewhat higher unless the new RNI for a given nutrient is sufficiently less than the RNI used in the 1998 report; this is why the desired protein density is higher in the second and third columns, even though new RNIs for protein have not yet been published.) The remaining columns of tables 10 and 11 show the median nutrient density of the complementary foods consumed by breastfed children in each study.

For each study, the values in these tables were calculated from weighed food-intake data converted to nutrients using appropriate local food-composition tables. The data from Bangladesh were obtained from 135 breastfed infants in nine rural villages in Matlab Thana, located 55 km southeast of Dhaka (personal communication, Kimmons JE, Dewey KG, Haque E, Chakraborty J, Osendarp S, Brown SH, University of California, Davis, Calif., USA, and International Centre for Diarrhoeal Disease Research, Bangladesh, 2002). Each child's intake was measured on a single day by an observer during a 12-hour period, and nighttime intake was estimated by maternal recall. For Ghana, the data are based on 12-hour weighed intakes of 208 breastfed infants in a town located about 400 km north of Accra [27]. These infants were enrolled in an intervention study to evaluate the effects of various "improved" complementary food blends: Weanimix, a blend of maize, soybeans, and peanuts; Weanimix plus fish powder; and a traditional fermented maize porridge (*koko*) plus fish powder. A fourth group, which received Weanimix fortified with vitamins and minerals, was excluded from these calculations except for their pre-intervention intake data at six months. At each dietary assessment (at 6, 7, 8, 10, and 12 months), food records were completed for a randomly selected subsample of 50% of the subjects. The data from Guatemala were

TABLE 10. Nutrient densities of complementary food diets consumed by infants aged 6 to 8 and 9 to 11 months in Bangladesh, Ghana, Guatemala, Peru, and the United States[a]

Age group and nutrient	Average desired			Median density				
	WHO/ UNICEF 1998 [1]	New DRI [22–25]	WHO 2002 [26]	Bangla- desh[b]	Ghana[c]	Guate- mala[d]	Peru[e]	USA[f]
6–8 mo								
No. of infants				50	207	194	107	36
Protein (g/100 kcal)	0.7	1.0	1.0	1.9	3.3	2.2	2.6	2.6
Vitamin A (µg RE/100 kcal)	5	81	31	0	7	87	35	95
Calcium (mg/100 kcal)	125	40	105	16	35	27	19	67
Iron (mg/100 kcal)	4.0[g]	5.3[g]	4.5	0.4	1.2	0.5	0.4	3.6
Zinc (mg/100 kcal)	0.8	1.1	1.6	0.2	0.6	0.4	0.4	0.4
Riboflavin (mg/100 kcal)	0.07	0.08	0.08	0.04	0.03	0.06	0.07	0.18
Thiamine (mg/100 kcal)	0.04	0.08	0.08	0.04	0.07	0.04	0.04	0.14
Niacin (mg/100 kcal)[h]	1.1	1.5	1.5	0.9	0.8	0.4	0.5	1.5
Niacin equivalent (mg/100 kcal)				1.3	1.3	0.8	1.0	
Folate (µg/100 kcal)	0	11	11	5	—	7	—	—
Vitamin B_6 (mg/100 kcal)	0.09[i]	0.12	0.12	0.02	—	0.05	—	0.10
Vitamin C (mg/100 kcal)	0	11	1.5	0	0.02	2.3	2.3	7.2
9–11 mo								
No. of infants				66	171	148	99	31
Protein (g/100 kcal)	0.7	1	1	2.5	3.1	2.7	2.6	3.4
Vitamin A (µg RE/100 kcal)	9	63	30	1	9	62	29	88
Calcium (mg/100 kcal)	78	32	74	20	40	37	27	53
Iron (mg/100 kcal)	2.4[g]	3.5[g]	3	0.4	1.3	0.6	0.4	1.2
Zinc (mg/100 kcal)	0.5	0.7	1.1	0.3	0.6	0.4	0.4	0.4
Riboflavin (mg/100 kcal)	0.04	0.06	0.06	0.05	0.02	0.06	0.07	0.08
Thiamine (mg/100 kcal)	0.04	0.06	0.06	0.05	0.06	0.05	0.04	0.1
Niacin (mg/100 kcal)[h]	0.9	1	1	1.0	0.7	0.5	0.5	1.1
Niacin equivalent (mg/100 kcal)				1.4	1.2	0.7	1.0	—
Folate (µg/100 kcal)	0	9	9	8	—	13	—	—
Vitamin B_6 (mg/100 kcal)	0.08[i]	0.08	0.08	0.03	—	0.07	—	0.10
Vitamin C (mg/100 kcal)	0	8	1.7	0.3	0.9	2.4	1.1	6.4

a. Shading indicates that the observed density is below at least two of the three reference values for the average desired density.
b. Kimmons JE, Dewey KG, Haque E, Chakraborty J, Osendarp S, Brown KH, University of California, Davis, and International Centre for Diarrhoeal Disease Research, Bangladesh, unpublished data, 2002.
c. Lartey et al., 1999 [27].
d. Brown KH, Santizo MC, Begin F, Torun B, University of California, Davis and Instituto Nutricional de Centro America y Panama, unpublished data, 2000.
e. Lopez de Romaña et al., 1989 [29]; Creed de Kanashiro et al., 1990 [30].
f. Heinig et al., 1993 [31].
g. Medium bioavailability of iron.
h. Excluding the contribution of dietary tryptophan to niacin synthesis.
i. Corrected value.

obtained during a micronutrient intervention trial that was conducted in a periurban community outside of Guatemala City [28]. Daytime food intake was measured by an observer. The Guatemalan values in tables 10 and 11 are based on breastfed infants only ($N = 194$), with two or three days of records for each child in each age interval (6 to 8 and 9 to 11 months). Nutrients provided by the intervention supplements are not included in the data. For Peru, the data are based on 12-hour weighed food intake records for 107

breastfed infants in Huascar, a periurban community on the outskirts of Lima [29, 30]. For each child, three to four days of records were available for each age interval. The US data are derived from the DARLING study, in which four-day weighed food intake records of 46 breastfed infants in Davis, California, were completed by their mothers at 6, 9, 12, 15, and 18 months [31]; the sample sizes in the tables are less than 46 because of missing data for some of the infants. For Mexico, the dietary intake of children in the rural town of Solis was

TABLE 11. Nutrient densities of complementary food diets consumed by infants aged between 12 and 23 months in Guatemala, Mexico, and the United States[a]

Nutrient	Average desired			Median density		
	WHO/ UNICEF 1998 [1]	New DRI [22–25]	WHO 2002 [26]	Guatemala[b] (116 infants 12–15 mo)	Mexico[c] (18 infants 18–23 mo)	USA[d] (22 infants 12–18 mo)
Protein (g/100 kcal)	0.7	0.9	0.9	2.5	3.0	3.2
Vitamin A (µg RE/100 kcal)	17	5	23	58	8	50
Calcium (mg/100 kcal)	26	63	63	24	60	49
Iron (mg/100 kcal)	0.8[e]	1.2[e]	1.0	0.6	0.6	1.1
Zinc (mg/100 kcal)	0.3	0.4	0.6	0.4	0.5	0.5
Riboflavin (mg/100 kcal)	0.05	0.06	0.06	0.05	0.04	0.1
Thiamine (mg/100 kcal)	0.05	0.07	0.07	0.05	0.04	0.08
Niacin (mg/100 kcal)[f]	0.9	0.9	0.9	0.5	0.6	1.0
Niacin equivalent (mg/100 kcal)				0.6	1.1	
Folate (µg/100 kcal)	0	19	21	13	14	–
Vitamin B$_6$ (mg/100 kcal)	0.09[g]	0.08	0.08	0.07	0.06	0.1
Vitamin C (mg/100 kcal)	1.1	0	1.5	2.6	0.8	4.7

a. Shading indicates that the observed density is below at least two of the three reference values for average desired density.
b. Brown KH, Santizo MC, Begin F, Torun B, University of California, Davis, and Instituto Nutricional de Centro America y Panama, unpublished data, 2000.
c. Allen et al., 1992 [32].
d. Heinig et al., 1993 [31].
e. Medium bioavailability of iron.
f. Excluding the contribution of dietary tryptophan to niacin synthesis.
g. Corrected value.

assessed by in-home measurements by an observer on multiple days [32]. The Mexican data shown here are for those children who still received breastmilk ($N = 18$ at 18 to 24 months), for whom there were 2 to 12 days of food records per child. (Note: the Mexican data differ from those in the 1998 report because the latter included all children in the Mexican study, not just the breastfed children.)

In all three age intervals, the median protein density in each of the populations (2.0 to 3.3 g/100 kcal) was considerably greater than the desired density (0.7 to 1.0 g/100 kcal). For the micronutrients shown in these tables, however, the picture is quite different, particularly for iron and zinc. At 6 to 8 months, the median iron and zinc densities were far less than the desired level in all five populations (regardless of which set of desired levels is used), and the same was true at 9 to 11 months, except for zinc density in Ghana. Iron and zinc intakes in Ghana were higher than those in the other developing countries, because two-thirds of the Ghanaian infants in these analyses were provided with a complementary food mix that included fish powder; the other third was provided with a maize-soybean-peanut blend. Even so, their intakes fell short of the desired levels for these two nutrients. At 12 to 23 months, the median iron density in Guatemala and Mexico was also less than all three sets of desired levels, and iron density in the United States was less than the desired level based on the new DRIs. In all countries, the median zinc density at 12 to 23 months was similar to or slightly greater than the first two sets of desired levels (the 1998 values and the new DRIs), but lower than the desired density based on the new WHO/FAO requirement.

The adequacy of observed calcium densities depends on which set of desired levels is used. In comparison with the 1998 desired levels or the new WHO/FAO requirements, all five populations had inadequate calcium densities at both 6 to 8 and 9 to 11 months. When the new DRIs were used, the median calcium density was also generally inadequate (except for the United States) at 6 to 8 months, but was generally adequate (except for Bangladesh and Peru) at 9 to 11 months. At 12 to 23 months, most of the populations had adequate calcium density with respect to the 1998 desired levels, but all had levels lower than the desired levels derived from the new DRIs or the new WHO/FAO requirements.

Most populations had adequate vitamin A density with respect to the 1998 desired levels (except Bangladesh at 6 to 8 and 9 to 11 months and Mexico at 12 to 23 months). When compared with the new DRIs, however, the observed densities at 6 to 11 months were considerably lower than desired in all populations except Guatemala and the United States, whereas none of the densities at 12 to 23 months were lower than desired. When compared with the new WHO/FAO values, vitamin A density was low in Bangladesh, Ghana, Peru, and Mexico. Vitamin A intakes were higher in Guatemala than in the other developing-country sites, because sugar in Guatemala is fortified with vitamin A.

For some of the water-soluble vitamins shown in the tables, the adequacy of the observed densities also depends on which set of desired levels is used. The observed densities of thiamine and folate were generally similar to or greater than the 1998 levels (except for thiamine in Mexico at 12 to 23 months) but were less than the levels based on the new DRIs or WHO/FAO values in many cases. In all populations, the observed vitamin C density at 6 to 8 and 9 to 11 months was less than the desired density based on the new DRIs, but greater than the 1998 desired density; when compared with the WHO/FAO desired density, the values were low in Bangladesh and Ghana (as well as Peru at 9 to 11 months). At 12 to 23 months, the observed vitamin C density was low only in Mexico (and only when compared with the 1998 or WHO/FAO levels).

By contrast, riboflavin and vitamin B_6 were problem nutrients in some populations, regardless of which set of desired levels was used. Riboflavin density was low or marginal in all populations except the United States. Information on the vitamin B_6 content of the diet was not available for all populations, but when it was, the density was low or marginal except in the United States at 9 to 11 and 12 to 23 months. Vitamin B_6 was not flagged as a problem nutrient in the 1998 report, because there was an error in the estimate of vitamin B_6 requirements from complementary foods in that document. The value that was used for vitamin B_6 content of human milk was taken from a previously published report prepared by the US Institute of Medicine [33], which overstated the vitamin B_6 content of breastmilk by an order of magnitude (93 mg/L rather than 93 µg/L). As a result, the amount required from complementary foods was correspondingly underestimated. The correct age-specific values for the vitamin B_6 content of complementary foods should have been 0.24 mg/day, 0.34 mg/day, and 0.65 mg/day for children aged 6 to 8, 9 to 11, and 12 to 23 months, respectively, indicating that complementary foods must provide a large percentage of the vitamin B_6 needs. Because vitamin B_6 deficiency has been associated with delayed growth and neurological abnormalities in infants [34, 35], it is important to recognize that it may be a problem nutrient.

Niacin is a special case because of the contribution of dietary tryptophan to niacin synthesis. Without considering tryptophan, the niacin densities were low in all populations, regardless of which desired level was used (except for Bangladesh at 9 to 11 months and the United States at all ages). Available food-composition tables provide only limited information on the tryptophan content of local foods. Therefore, we estimated the niacin equivalents (NE) based on the approximate ratio of tryptophan to dietary protein in the USDA food-composition database (about 10 mg tryptophan for every gram of protein). The total NE density was generally adequate except in Peru at six to eight months

and Guatemala at all ages.

Some nutrients (e.g., vitamin E, iodine, and selenium) were not included in tables 10 and 11 because food-composition data were lacking or there was a high degree of natural variability depending on factors such as storage conditions and water or soil content. They may very well be problem nutrients in some populations. Similarly, vitamin D was not included, because it is assumed that exposure to the sun will be adequate for photoconversion in the skin, but this may not be the case in areas of high latitude or where infants are kept shielded from the sun or sunscreens are commonly used. For the nutrients included in these analyses, the values in tables 10 and 11 should be interpreted with caution because of the limitations of food-composition databases. Data were sometimes missing for particular foods, in which case appropriate substitutions were made. However, there is considerable judgment involved in making such substitutions because of uncertainty about the nutritional comparability of various foods. Nonetheless, it is remarkable that the observed nutrient densities were quite similar across populations in most cases; when they were not, there was usually an obvious reason (such as use of fortified foods or dependence on a particular staple food).

In summary, these analyses suggest that iron, zinc, and vitamin B_6 are problem nutrients in most developing-country populations, and riboflavin and niacin are problem nutrients in certain populations. Even in the United States, iron and zinc are problem nutrients in the first year of life, despite the availability of iron-fortified products. The judgment about calcium, vitamin A, thiamine, folate, and vitamin C depends on which set of desired levels is deemed most appropriate. If one uses the new WHO/FAO requirements, folate, thiamine, and calcium would be considered problem nutrients in many developing-country populations, and vitamin A and vitamin C would be problem nutrients in some situations.

Until more information is available, the "desired" nutrient densities shown in tables 10 and 11 should not be used as reference values. First, as mentioned earlier, there is a need for expert review regarding the most appropriate RNI to use for each nutrient when developing nutrient density recommendations for this age range. Second, there is still uncertainty regarding breastmilk concentrations of certain nutrients, and thus the amounts needed from complementary foods. In the case of vitamin B_6, for example, the breastmilk concentration used in the 1998 report is based on a single study in which there were only six women not taking vitamin B_6 supplements. Nonetheless, the general picture emerging from the data in tables 10 and 11 is that multiple micronutrients are likely to be limiting in the diets of children aged between 6 and 24 months in developing countries.

Strategies for obtaining needed amounts of problem nutrients

Optimizing nutrient intake from locally available foods

The comparisons described above are based on observed intakes of complementary foods as chosen by the carers, and the mix of foods offered (and the way they are prepared) may not be optimal to meet nutrient needs. This section will discuss strategies by which to improve the nutritional quality of a diet based on locally available foods.

One of the challenges in developing dietary guidelines for optimizing nutrient intake is the large number of nutrients that have to be considered simultaneously. A mathematical approach that can accomplish this is linear programming, which is used to minimize a linear function (e.g., cost) while fulfilling multiple constraints expressed in a linear form (e.g., nutrient needs) [36, 37]. In its simplest form, linear programming merely requires knowing the nutrient composition and cost of local foods and the nutrient requirements to be met. However, the resulting "solution" (i.e., the lowest-cost combination of foods that will meet nutrient needs) may dictate the consumption of an excessive amount of energy from complementary foods. For this reason, constraints need to be imposed on the model with regard to the total amount of energy that can reasonably be consumed by children in each age interval while still allowing for typical intakes of breastmilk. Furthermore, it may be necessary to impose constraints on the maximum amount of each individual food that can reasonably be consumed to avoid a solution that is unrealistic (e.g., a single food providing more than two-thirds of energy from complementary foods). Finally, bioavailability constraints need to be included (which may require nonlinear techniques) so as to adjust for the effects of components such as phytate on the estimated amount of certain micronutrients (e.g., iron and zinc) that can be absorbed.

Deshpande et al. [38] recently applied this technique to dietary data collected from 135 Bangladeshi infants 9 to 12 months of age, using the RNIs cited in the 1998 report. With all of the above constraints in the model, it was not possible to fulfil nutrient needs solely with locally available foods. The limiting nutrients were iron and calcium. Even with animal-source foods in the diet (eggs, fish, and milk), the iron "gap" relative to needs was 7 mg, and the calcium "gap" was 130 mg. Addition of micronutrient supplements to the model made it possible to meet nutrient needs, and the resulting diet was of lower cost than the diet that included animal-source foods without supplements. Linear programming techniques can be used to obtain a list of foods that (when consumed in the amounts prescribed) come as close as possible to meeting nutrient requirements at the lowest cost. The combination of foods identified can be used as the "model local diet," recognizing that the gaps in the limiting nutrients may need to be filled using other strategies, such as micronutrient supplements or substitution of fortified complementary foods for some of the foods in the model local diet. By knowing the magnitude of the shortfall for each of the limiting nutrients, the cost of these other components can be kept to a minimum. In this fashion, it is possible to tailor the dietary guidelines and intervention strategies to the actual dietary practices of each population.

Besides identifying the most nutritious combinations of local foods, there are other methods for improving dietary quality that may be appropriate in certain situations. For example, the content of bioavailable iron and zinc in home-prepared diets can be enhanced by reducing phytate concentrations through germination, fermentation, and/or soaking; by reducing intake of polyphenols, which are abundant in coffee and tea and are known to inhibit iron absorption; by increasing the intake of enhancers of iron and zinc absorption, such as ascorbic acid (for absorption of nonheme iron) and other organic acids (for absorption of both zinc and nonheme iron; these include citric, malic, tartaric, and lactic acids, some of which are produced during fermentation); and by including animal products in the meal, which promote the absorption of iron and zinc from plant-based foods [39]. Fermentation is a promising approach, not only because it enhances iron and zinc bioavailability, but also because it increases the levels of several B vitamins.

Similar issues of bioavailability may apply to plant sources of provitamin A carotenoids. There is some evidence that orange fruits (e.g., papaya, mango, and pumpkin) are more effective than dark-green leafy vegetables for improving vitamin A status [40]. Orange fruits may also be a more acceptable option because in many cultures there is reluctance to feed dark-green leafy vegetables to infants. Likewise, calcium bioavailability is a concern in some plant foods (such as dark-green leafy vegetables) that have a high content of oxalates, which inhibit calcium absorption [41]. Therefore, when there is a choice of calcium-rich plant foods, it may be preferable to select those with low oxalate content.

Aside from nutrient content, the risk of microbial contamination is an important consideration in designing complementary feeding diets. Although the main strategy for increasing calcium intake is to include dairy products, in disadvantaged populations the promotion of liquid milk products is risky because they are easily contaminated, especially when fed by bottle. Fresh, unheated cow's milk consumed prior to 12 months of age is also associated with fecal blood loss and lower iron status [42, 43]. For these reasons, it may be more appropriate to use items such as cheese, dried milk, and yogurt. Fermentation has been shown to reduce the risk of microbial contamination in complementary foods. In a recent study in 50 households

in Ghana [44], the coliform counts of a maize-legume porridge prepared in the morning and sampled in the evening were reduced by 50% when the food included maize that had been fermented and dried prior to its incorporation into the dry product before cooking, in comparison with the porridge that included unfermented maize.

Improving the nutritional quality and microbiological safety of home-prepared complementary foods using the strategies described above can go a long way towards improving the nutritional status of young children. However, even with use of techniques to enhance micronutrient bioavailability, plant-based complementary foods by themselves are insufficient to meet the needs for certain nutrients (particularly iron, zinc, and calcium) during the period of complementary feeding [39]. Inclusion of animal products can meet the gap in some cases, but this increases the cost and may not be feasible for the lowest-income groups. Furthermore, the amounts of animal products that can feasibly be included in complementary foods in developing countries are generally not sufficient to meet the gaps in iron, calcium, and sometimes zinc. Gibson et al. [39] evaluated 23 different complementary food mixtures used in developing countries, some of which included animal products. Although most met the protein and energy needs, none met the desired iron density and few met the desired calcium or zinc density. Thus, strategies to optimize nutrient intake from locally available foods may need to be coupled with other approaches in order to fully address the problems of micronutrient malnutrition.

Micronutrient supplements

Given that it is very difficult to meet micronutrient needs from home-prepared foods, the option of micronutrient supplementation should be considered. This can be accomplished either through direct administration of liquid supplement "drops" or crushable tablets to the child, or by mixing a micronutrient preparation (e.g., "sprinkles" or a fat-based spread) with the complementary foods given to that child. To date, most of the experience with direct micronutrient supplementation has been with single nutrients, particularly vitamin A. Vitamin A supplementation programs have largely been successful in improving the vitamin A status of preschool children in deficient populations, but there are concerns about coverage (particularly of infants) and sustainability [45]. Because vitamin A is a fat-soluble vitamin and is stored in the liver, infrequent high-dose supplementation is effective. However, this is not the case for iron and zinc, which must be administered more frequently in relatively small doses to be safe and effective. In the past few years, there has been increasing interest in supplements that combine several key micronutrients. Data from several trials to evaluate the efficacy of iron-zinc combinations and multiple

micronutrient tablets for infants should be available soon. The advantage of direct supplementation is that the dose and form of the nutrients (i.e., bioavailability) can be specified to ensure that the infant absorbs the appropriate amount, although uncertainties remain about the interactions among nutrients and between supplemental nutrients and food components. The disadvantages include the risk of accidental poisoning of children in the household, the cost of supplements and containers, potentially low compliance if caregivers believe that the supplements cause adverse reactions or tire of giving them every day, and dependency on a distribution system based outside the local community.

The use of micronutrient preparations that can be mixed with complementary foods in the household may avoid some, though not all, of the disadvantages listed above. Micronutrient sprinkles have been developed that use encapsulated forms of some of the nutrients to permit multiple nutrient combinations with acceptable stability and taste (personal communication, Zlotkin S, The Hospital for Sick Children, Toronto, Ontario, Canada, 2000). These can be packaged in single-dose packets, to be mixed once a day with whatever food is typically fed to the infant. To date, sprinkles have included combinations of two or more of the following nutrients: iron, vitamin C, zinc, vitamin A, and iodine. Data from efficacy trials should be available soon. The results from the first set of trials, which tested sprinkles with iron and vitamin C to treat anemic children aged 6 to 24 months in Ghana, indicate that they are as effective as iron sulfate drops [46]. The results of studies with other nutrient combinations are forthcoming, and additional research is planned on the bioavailability of nutrients provided in this form and on adding pre- and/or probiotics to the packets to enhance resistance to infection.

Another product, which is a fat-based spread (like peanut butter) fortified with multiple micronutrients, has been developed by the Institute de Recherche pour le Developpement (Paris) and Nutriset (Malaunay, France). This product was originally developed for the rehabilitation of malnourished children, as an alternative to the WHO F100 liquid diet [47], and was intended to serve as a ready-to-use food that has high energy and nutrient density. Initial studies documented that it was better accepted than the WHO F100 liquid diet [47], and relief agencies have been using it successfully in famine situations. Following development of the original product, the company has designed new products with higher concentrations of vitamins and minerals. One of these products, which was evaluated in refugee children three to five years of age in Algeria [48], was very well accepted and was associated with reductions in stunting and anemia. No adverse reactions to the peanut-based spread were reported. With the high-nutrient-density versions of this product, only a spoonful per day is needed to meet the micronutrient

needs of infants. This can be mixed with whatever complementary food is normally available. There are several advantages to this product: because it is fat-based and contains no water, the micronutrients included in the spread are protected from oxygen and cannot react among themselves, which leads to a longer shelf-life than that of a powder or flour; the fat in the product increases the energy density of the complementary food and may aid in the absorption of fat-soluble vitamins; because there is no water in the product, it is safe from bacterial proliferation and probably will not support growth of pests such as weevils; if desired, enzymes such as amylase can be incorporated into the spread if it is to be mixed with a viscous porridge; and the technology to produce the spread is simple and can be adopted by communities using local foods (e.g., peanuts or other fat-rich legumes) with addition of the fortificants. Efficacy trials of its use for complementary feeding of infants have not yet been conducted, but acceptability trials in Bangladesh (personal communication, Kimoons JE, Dewey KG, Haque E, Chakraborty J, Osendarp S, Brown KH, University of California, Davis, Calif., USA, and International Centre for Diarrhoeal Disease Research, Bangladesh, 2002) and Ghana (personal communication, Lartey A, Johnson-Kanda I, University of Ghana, Legon, Ghana, 2000) indicate that it is well accepted by both mothers and infants.

Both the micronutrient sprinkles and the fat-based spread have the advantage of being adaptable to any feeding practices with little education required for their use. Caregivers may find them more convenient to use than liquid or tablet supplements because they can be mixed directly with food. The sprinkles are packaged in individual packets, whereas the spread can be packaged either in individual packets or in a larger container. No cost comparisons have been made yet. Per dose of micronutrients, the cost of the spread can be kept low by using the minimal amount of the food base (e.g., peanuts). For both the sprinkles and the spread, the bioavailability of certain nutrients may be influenced by the complementary food with which they are mixed, although these effects could potentially be avoided for the minerals by chelating them with ethylene diaminetetraacetate (EDTA). There may be less risk of accidental poisoning with sprinkles or spreads, because they may be less tempting to young children than the sweet formulations usually used for liquid drops or tablets. However, these features (convenience, bioavailability, and risks) have not yet been formally evaluated. Further research is needed to assess the efficacy and effectiveness of these strategies for ensuring adequate intakes of micronutrients.

Fortified processed complementary foods

Processed complementary foods have been part of the repertoire for improving infant nutrition for decades and have usually involved various combinations of cereals, legumes, and other foods (often dried milk) to provide a high-protein, predominantly plant-based food suitable for infants. Although the objective was to develop low-cost foods, many of these products were still not affordable by poor families and therefore had little impact on the prevalence of child malnutrition. In recent years, however, there has been renewed interest in processed complementary foods, for several reasons. First, with advances in scientific knowledge, there has been a shift from focusing on protein to ensuring that micronutrient needs are met. Fortified foods are a convenient way to achieve this. Second, improvements in manufacturing techniques and local production of blended cereal products have made processed foods more affordable for low-income families. Third, with increased urbanization and employment of women, there is greater demand for precooked products that require less time and effort to prepare.

The optimal characteristics of processed complementary foods are discussed in another background paper by Lutter [49] and will not be reiterated here. One of the difficulties in using fortified foods to meet micronutrient needs is that the intakes of processed complementary foods may have a 10-fold range, from less than 25 g to more than 250 g of dry food per day, depending on the age of the infant and the amount of breastmilk and other foods consumed. A food formulated for children in the second year of life is unlikely to have sufficient nutrient density to meet the nutrient needs of children less than 12 months of age, whereas a food formulated for infants may result in excessive intakes of certain nutrients by older children [50]. Different formulations can be developed for children of different ages, but they would need to be accompanied by effective educational messages regarding their appropriate use.

The advantages of processed complementary foods include convenience, the ability to provide an appropriate balance of nutrients, the possibility of reducing microbial contamination by using instantized and/or fermented products, and potential time savings for caregivers. The disadvantages include cost (although the cost relative to that of other alternatives may be favorable), variable adequacy of micronutrient density and lack of control over the "dose" of nutrients consumed by the child, the need for a distribution network and systems for quality control, and the potential for creating dependency and undermining local agriculture (unless local foods are used for the product). Such products may be most appropriate for urban households that do not grow their own foods and value the convenience of a precooked product. In rural areas of developing countries where foods are primarily home grown and incomes are lower, centrally processed complementary foods may be less appropriate. Whatever the setting, processed complementary foods should not be considered the sole component of a comple-

mentary feeding program. Planners need to recognize that a carefully developed social marketing campaign must accompany any program to promote processed complementary foods. When a coordinated strategy is used, appropriate marketing of such foods can provide an opportunity to educate caregivers about appropriate food-preparation and feeding practices, including sustained breastfeeding.

Interaction between breastfeeding and complementary feeding

Degree of displacement of breastmilk by other foods

Many programs to improve complementary feeding have not paid enough attention to avoiding excessive displacement of breastmilk by complementary foods. Although messages to "continue breastfeeding" are usually included, they generally do not specify how mothers can maintain an optimal milk supply. Because infants are quite good at self-regulating their energy intake to meet their needs, they will reduce their breastmilk intake when given a large amount of energy from other foods. As a result, some complementary feeding programs may unintentionally compromise breastfeeding by advocating feeding complementary foods too often or providing too large a proportion of the infant's energy needs from complementary foods.

The degree of displacement of breastmilk by non-breastmilk foods appears to depend on age. In the first six months of life, each kilocalorie from non-breastmilk sources displaces about 0.6 to 1.7 kcal from breastmilk; after six months, the proportion displaced appears to be lower (about 0.3 to 0.4 kcal) [51]. However, the latter estimate is based on only two studies (Thailand and Peru), both of which used data from observational studies to examine the association between energy from complementary foods and energy from breastmilk. When nursing frequency was controlled for, in both cases there was still a significant inverse association between these two variables, which implies that even with maintenance of the number of breastfeedings, there will be some displacement of breastmilk. The ideal design for testing this hypothesis is a randomized, controlled trial, but no such studies have been conducted in infants older than six months. In two randomized trials in Honduras [52, 53] that examined this question during the period from four to six months, the breastmilk intake declined when complementary foods were given, even when nursing frequency was maintained.

It thus appears that some displacement of breastmilk is inevitable when complementary foods are consumed. With age, it is of course expected that children will eventually be completely weaned from breastmilk. Thus, the goal is not to sustain the same intake of breast-

milk indefinitely, but to determine what is the optimal ratio of energy from breastmilk to energy from complementary foods at various ages. This is not a simple task, and in any case the answer will depend on the setting.

Nutritional tradeoffs

The nutritional tradeoff between breastmilk and complementary foods depends on the quality of the complementary foods. Using data from the study in Bangladesh described previously (personal communication, Kimmons JE, Dewey KG, Haque E, Chakraborty J, Osendarp S, Brown KH, University of California, Davis, Calif., USA, and International Centre for Diarrhoeal Disease Research, Bangladesh, 2002), we calculated the theoretical changes in nutrient intake if an infant consumed an additional 100 kcal of complementary food with a nutrient density representing the average for that population. In this sample of infants (aged 6 to 12 months), the displacement was estimated to be 43 kcal of breastmilk for every 100 kcal of complementary food. The intake of an additional 100 kcal of complementary food would thus be expected to yield a net gain of 57 kcal. This increase would result in a 20% increase in protein intake, but only a small increase in the intakes of iron, zinc, calcium, and riboflavin (2% to 9% of the RNI), and a net decrease in the intakes of vitamins A (–2% of the RNI) and C (–4% of the RNI). The estimates for iron, zinc, and calcium do not take into account the potential differences in bioavailability from complementary foods and breastmilk. These calculations indicate that a greater intake of the typical complementary foods in this population would not substantially improve the micronutrient intake of the infants and might even have adverse effects on micronutrient status if the foods are contaminated and lead to greater morbidity. Of course, the situation would be very different if the nutrient quality of the complementary foods was improved.

Other potential consequences of displacement of breastmilk

Aside from nutritional tradeoffs, displacement of breastmilk may have health consequences for both the infant and the mother. For the infant, reduced intake of the anti-infective components of human milk may increase the risk of infection. For the mother, reduced suckling frequency and intensity may decrease the duration of lactational amenorrhea and increase the chances of becoming pregnant sooner (if other contraceptives are not used). Thus, in populations where these outcomes are undesirable (e.g., they pose health risks for the mother and the current child), it is particularly important to sustain breastmilk intake as much as possible.

Possible strategies for optimizing nutrient intake and infant and maternal health

There is very little information on how to maximize breastmilk intake during the period of complementary feeding. Theoretically, the degree of displacement could be affected by the frequency of meals, the energy density of complementary foods, the timing of breastfeedings (before or after meals), and the mode of feeding (cup, spoon, or bottle). In Guatemala, an intervention designed to promote five meals per day caused a reduction in the time spent on breastfeeding for certain age groups [54], which strongly suggests that breastmilk intake declined as meal frequency increased. In Nigeria, consumption of a more energy-dense porridge resulted in displacement of other complementary foods, but not breastmilk [55]. Generalizing from just two studies in different populations is risky, but they may imply that interventions to increase energy density are less likely to interfere with breastfeeding than interventions to increase meal frequency.

Drewett et al. [56] examined whether the timing of breastfeedings (before or after meals) influenced the degree of displacement. Breastmilk intake and total time nursing were measured under three different feeding regimens for 36 infants in the United Kingdom, ranging in age from 17 to 43 weeks. On one day the infant was fed solid foods before breastfeeding, on another day the solid foods were fed after breastfeeding, and on a third day no solids were given. Each of the six possible orders of days was followed by six of the infants. Breastmilk intake was lower on the two days on which solid foods were given than on the day with no solids. When solid foods were fed before breastfeeding, the milk intake was lower than when solid foods were fed after breastfeeding. However, over the entire 24-hour period, there was no significant difference in either total breastmilk intake or total time at the breast between days on which solids were given before breastfeeding and days on which solids were given after breastfeeding. This indicates that the infants compensated for the order effect of a given meal by consuming more or less breastmilk at other feedings during the day and night. On the basis of this one study, the timing of meals does not appear to affect the degree of displacement. It has long been believed that bottle-feeding is more likely to displace breastmilk than feeding by cup or spoon. No studies on this question could be located. From an energy point of view, if infants are perfect at self-regulating their intake, it should make little difference how the foods are fed. However, if part of the drive for feeding is to satisfy suckling needs, or if it is simply easier for infants to consume large quantities by bottle, they may prefer liquid foods given by bottle and thus consume more of them than if the foods are given in other ways. There is also the possibility that infants may develop a preference for an artificial nipple over the breast, which can result in complete weaning.

Given the paucity of research data, what can be recommended? Because infants' energy needs vary with their age, size, and state of health, there is no single prescription for avoiding excessive displacement of breastmilk. The standard advice to breastfeed as often as the infant desires is probably the most important recommendation. The guidelines for meal frequency discussed earlier are reasonable estimates until further information is available. It is difficult for some mothers to breastfeed before the family meal (e.g., when they are in the midst of preparing the meal, or when the child has not recently been breastfed and is reaching for other foods), and it probably does not matter whether the child is breastfed before or after the meal. Teaching caregivers to be sensitive to the child's hunger and satiety cues, i.e., feeding until the child rejects further food and not force-feeding, is sensible advice. Avoidance of bottle-feeding is advisable, not only because bottles may cause greater displacement of breastmilk, but also because they increase the risk of contamination in settings with poor environmental sanitation.

It should be mentioned that in some cases the infant may be overly dependent on breastmilk and consuming insufficient complementary foods to meet nutrient needs. In these cases, assuring that the infant's appetite is not compromised by illness or micronutrient deficiencies is the first step. If those causes are ruled out, offering complementary foods before breastfeeding may be advisable, although no studies have been conducted to evaluate this strategy.

Impact of improved complementary foods on child growth

What impact on growth can be expected from programs to improve complementary feeding? As described in the 1998 WHO/UNICEF report [1] and another recent review [57], the results are mixed. The studies conducted can be divided into efficacy trials of food or multiple micronutrient supplements, and nutrition education interventions that usually included multiple objectives, not just improved complementary feeding.

Efficacy trials of food or multiple micronutrient supplements

The efficacy trials conducted in developing countries have varied considerably in design, foods provided, initial age of the children, duration of the intervention (from 3 to 12 months), and outcomes measured. Detailed descriptions of each of the studies are provided elsewhere [57]. Among the 10 trials in developing countries that provided complementary foods, there was a positive effect on linear growth only in Sudan, Senegal, and Ghana, all in Africa. In this region, growth

faltering appears to be more pronounced postnatally than prenatally and thus may be more amenable to change by postnatal nutritional interventions. There are several possible reasons for the lack of effect on linear growth in the other sites. First, the children may have had an adequate initial nutritional status. Second, in several projects the intervention started before the age of six months, when complementary feeding is unlikely to have a beneficial impact and may have adverse consequences. Third, some studies did not include enough infants under 12 months of age, when faltering is most dramatic. Fourth, there were serious methodological limitations in several projects, such as lack of a comparison group that received no intervention, small sample size, short duration of the intervention, and possible attrition bias. Last, there may have been constraints on child growth responses due to infections, long-term effects of prenatal malnutrition, or intergenerational effects of maternal malnutrition. Unfortunately, none of the complementary feeding trials measured breastmilk intake, so it is not possible to calculate the net change in total nutrient intake. As described in the previous section, there is a risk of interfering with breastfeeding if food is given too frequently or in very large quantities. This may have been the case in a study in India, where the rates of fever and dysentery were higher in the group provided with processed fortified foods than in the control group [58].

The impact of multiple micronutrient supplements has been assessed in several populations (Vietnam, Peru, Guatemala, Mexico, and Gambia; see Dewey [57]). These studies are included here because they provide information about the potential impact of adding micronutrients to complementary foods. In two of these five trials (Vietnam and Mexico), there was a positive impact on growth. In Vietnam, the effect on linear growth was observed only among the stunted children. This is consistent with the findings of a meta-analysis of zinc supplementation studies showing that zinc supplements have a greater effect on linear growth in stunted than in nonstunted children [59]. Of the micronutrients included in these studies, zinc is the most likely candidate for causing a growth response, since iron and vitamin A supplements have not produced consistent effects on the growth of children under two years of age [60].

Nutrition education trials

Nutrition education or social marketing strategies have been used to improve complementary feeding practices in several developing countries. Caulfield et al. [61] recently reviewed 16 such programs in 14 different countries. The programs generally included formative research to assess current practices and beliefs and develop appropriate recipes for enriched complementary foods using local ingredients, fol-lowed by recipe trials to determine the acceptability and feasibility of the foods to be promoted. The foods developed were usually grain-based porridges enriched with good sources of protein, energy, or micronutrients. Although these foods were nutritionally superior to the traditional complementary foods in each setting, there was usually little quantitative estimation of the improvement in nutrient intake (particularly for micronutrients) that might result from their use.

Most of the programs took a comprehensive approach to improve infant feeding practices in general, not just complementary foods *per se*. Key messages usually included exclusive breastfeeding for four to six months, feeding complementary foods three to five times per day, use of selected nutrient-rich foods or recipes, age-appropriate guidelines regarding the consistency of the foods, feeding during and after illness, hygienic methods of food preparation and storage, and continuance of breastfeeding.

Most of the programs that evaluated infant growth reported a positive impact. However, it is risky to attribute these effects only to improved complementary foods, because nearly all the programs also included messages to improve breastfeeding practices, particularly the duration of exclusive breastfeeding. One exception was a project in Bangladesh [62] that focused primarily on improving complementary feeding through nutrition education (without additional messages to promote exclusive breastfeeding through four to six months). After about five months, there was a highly significant difference in the weight-for-age of the intervention group (length was not measured). The intervention group was far more likely than the control group to have been given fish, eggs, or meat (68% vs. 13%), vegetables or fruits (66% vs. 7%), and oil (31% vs. 0%) during the previous 24 hours. Although caution is needed in drawing conclusions from this study because of its nonrandomized design, the results suggest that nutrition education approaches can be effective, even under impoverished conditions.

Several recent interventions with relatively strong study designs have provided additional insights. In Congo,* mothers in the intervention zone received nutrition education sessions in groups or at home by local educators who encouraged recommended feeding practices and demonstrated the preparation of improved complementary foods using cassava, peanut or pumpkin butter, and malted maize flour. Despite positive changes in maternal knowledge and practices, there was no improvement in the growth of children aged 4 to 27 months, which led the investigators to conclude that micronutrient deficiencies and/or other

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* Tréche S. Development and evaluation of strategies to improve complementary feeding in the Congo. Presented at a Heinz-UNICEF-SEAMEO International Workshop on Infant Feeding in Jakarta, Indonesia, October 27–28, 1997.

factors may have limited the growth response to the improved foods. By contrast, a positive effect on growth was observed following a nutrition education campaign in China that emphasized exclusive breastfeeding for four to six months, avoidance of bottle-feeding, feeding of egg yolk daily after four to six months, and other advice regarding complementary feeding [63]. Significant differences between the intervention and control group communities were seen at 12 months of age in both weight-for-age (difference of 0.76 Z score) and height-for-age (difference of 0.64 Z score). In Ghana, the Credit with Education program conducted by Freedom from Hunger was evaluated with the use of a randomized, controlled design [64]. This program coupled a microcredit program for women with education in the basics of health, nutrition, birth timing and spacing, and small-business skills. The nutrition topics focused on promotion of exclusive breastfeeding for about six months; use of complementary foods enriched with ingredients such as fish powder, peanuts, beans, egg, milk, and red palm oil (a good source of vitamin A); nutritious snacks such as mashed fruits and vegetables; increased feeding frequency; dietary variety; hygienic practices; and feeding during and after illness. The program had large effects on feeding practices, and there was an improvement in the weight and height of children aged 12 to 24 months (approximately 0.4 to 0.5 Z scores in comparison with changes in the control communities). Because of the multiple components of the Credit with Education program, it is difficult to disentangle which of the changes were responsible for improved child growth. Nonetheless, the results are illustrative of the magnitude of the impact that can be expected when complementary feeding messages are incorporated into a comprehensive program to meet the needs of both women and children.

Integrated approaches that incorporate nutrition education about complementary feeding into growth-monitoring and health programs have also shown success in improving child growth. The "hearth" model, which focuses primarily on rehabilitation of malnourished children using a "positive deviance" strategy [65], has been evaluated in Haiti [66] and Vietnam [67]. The most positive impact was seen in Vietnam, where the prevalence of severe underweight decreased from 23% to 6% in the implementation communities. The nutrition counseling component of the Integrated Management of Childhood Illnesses (IMCI) program has been evaluated by a randomized trial in Brazil [68]. Training of doctors resulted in improved consultations with patients, better complementary feeding practices, and an improvement in weight (and a nonsignificant improvement in length) among children aged 12 months or more.

Summary

To summarize, the effect of complementary feeding interventions on growth is variable and probably depends on the types of foods promoted, the target age range, the initial nutritional status of the infants, and the degree to which other nutrition and health messages are included in the program. When interventions include an emphasis on breastfeeding (particularly exclusive breastfeeding for the first six months), not just improved complementary foods, a growth effect is more likely to be observed. Thus, comprehensive approaches that address the full range of child-feeding practices are needed.

These findings indicate that program planners should be realistic about the magnitude of improvement in child growth that is achievable through complementary feeding programs. The growth response may be less dramatic than hoped, in part because postnatal growth is constrained by prenatal growth retardation and parental size. It will probably require several generations and greater attention to nutrition prior to and during pregnancy to eliminate stunting. This is one reason to include measurement of multiple outcomes (such as micronutrient status and neurobehavioral development), not just growth, in evaluating the impact of complementary feeding programs.

Components of successful complementary feeding programs

Although there is no "magic bullet" for improving complementary feeding, a well-planned approach can be highly effective. The approach should be systematic, i.e., the activities described below should be followed in order; participatory, i.e., the target group is actively involved in the planning and implementation stages; and coordinated, i.e., all the agencies and programs that deal with maternal and child health should be involved. Several excellent comprehensive manuals are available that describe in detail the activities to be undertaken in planning and implementing such a program [69–75]. Briefly, the steps described below are recommended.

1. Assess actual feeding practices, nutrient deficiencies, and factors that influence complementary feeding

This requires collection of information on breastfeeding patterns, dietary intake of young children, the carer's beliefs and attitudes towards child feeding, existing programs targeting maternal and child health, and the socioeconomic and demographic characteristics of the target group. Information on the prevalence of micronutrient deficiencies in children under two years old (e.g., anemia, low serum vitamin A) is also very useful.

2. Choose appropriate and cost-effective strategies for the target population

In this phase, data collected during the assessment phase are analyzed to decide whether the rates of exclusive breastfeeding for six months need improvement; whether the energy density of the complementary foods is adequate, given the typical meal frequency; which nutrients are most lacking in the diets of young children, and whether local foods are sufficient to meet the nutrient gaps; whether the total energy intake is low and, if so, the likely reasons; whether feeding behaviors, including hygienic practices, are in need of improvement; and what types of interventions are likely to be acceptable to the local population, taking into consideration the cost of, convenience of, and constraints to the adoption of new practices and/or foods. The linear programming techniques mentioned earlier are recommended during this phase. With this information, various intervention options can be ranked according to their feasibility and likelihood of impact, and the most appropriate option or options can be chosen for evaluation in the next step.

3. Conduct feasibility and acceptability trials

Before mounting a full-scale program, it is essential to evaluate its feasibility and acceptability in the local context. Qualitative approaches, such as focus groups, behavioral change trials, and recipe trials are useful methods for this stage. The guidebook "Designing by Dialogue" [69] includes detailed instructions for conducting recipe trials and trials of improved practices. A field guide for using the hearth model (based on the positive deviance approach) is also available [70].

4. Develop a delivery system, including educational and marketing components

Regardless of whether the intervention chosen includes provision of processed foods or nutrient supplements, or is based solely on behavioral change, there will need to be a delivery system that includes an educational and marketing component. The degree of involvement of the private and public sectors needs to be decided, but whatever the approach, input from the target community is critical. Procedures for developing a communications strategy are described in several guides [69, 71].

5. Implement the program in coordination with existing programs

The implementation phase requires a well-coordinated system for integration with ongoing programs. Complementary feeding messages should already be a part of growth-monitoring programs, but there may be limitations in terms of coverage and time for counseling. Rather than mounting a separate program, it is useful to consider ways to augment the existing network. Just as essential is the need to ensure that the messages promoted through a complementary feeding program are consistent with the messages promoted through other channels, such as breastfeeding promotion campaigns and maternal and child health initiatives, and with current scientific knowledge.

6. Set up monitoring and evaluation systems

It goes without saying that a well-designed program includes monitoring and evaluation of both operating effectiveness (coverage, leakage, efficiency, and sustainability) and impact (behavioral change, child growth, micronutrient status, and other indicators). When beginning a new program, it is useful to consider phased implementation to allow for a control group (communities not yet included in the program, preferably randomly assigned to control versus intervention). The control communities can then be assessed along with program communities both before and after implementation to permit evaluation of the impact. Documenting the impact is critical for defending the maintenance of a successful program when the political climate changes.

Policy implications

This review has identified a number of issues that warrant prompt attention as national and international institutions move forward with programs to improve complementary feeding. First, the new information on total energy requirements should be utilized to generate revised recommendations regarding the amount of energy required from complementary foods. Second, the recommendations in the 1998 WHO/UNICEF report regarding feeding frequency, energy density, lipid content, and nutrient density of complementary foods should be revised in light of these changes in energy recommendations. Third, appropriate efforts should be made to harmonize existing information on nutrient requirements during the age range of 6 to 24 months. Whenever possible, these should be based on physiological needs rather than observed intakes. This step is essential for developing scientifically based recommendations on the nutrient density of complementary foods and for identifying problem nutrients in specific populations. Last, there are many research questions that must be resolved in order to optimize the efficacy and effectiveness of complementary feeding programs. These have been highlighted in the individual sections of this paper and will not be reiterated here.

References

1. WHO/UNICEF. Complementary feeding of young children in developing countries: a review of current scientific knowledge. (WHO/NUT/98.1) Geneva: World Health Organization, 1998.
2. Butte NF. Energy requirements of infants. Eur J Clin Nutr 1996;50:S24–36.
3. Torun B, Davies PSW, Livingstone MBE, Paolisso M, Sackett R, Spurr G. Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. Eur J Clin Nutr 1996;50:S37–81.
4. FAO/WHO/UNU. Energy and protein requirements. (WHO Technical Report Series, No. 724). Geneva: World Health Organization, 1985.
5. Butte NF, Wong WW, Hopkinson JM, Heinz CJ, Mehta NR, Smith EOB. Energy requirements derived from total energy expenditure and energy deposition during the first 2 years of life. Am J Clin Nutr 2000;72:1558–69.
6. WHO Working Group on Infant Growth. An evaluation of infant growth. Geneva: World Health Organization, 1994.
7. Gonzalez-Cossio T, Habicht JP, Rasmussen KM, Delgado HL. Impact of food supplementation during lactation on infant breast-milk intake and on the proportion of infants exclusively breast-fed. J Nutr 1998;128:1692–702.
8. Milner JA, Allison RG. The role of dietary fat in child nutrition and development: summary of an ASNS workshop. J Nutr 1999;129:2094–105.
9. Bier DM, Brosnan JT, Flatt JP, Hanson RW, Weird W, Hellerstein MK, Jequier E, Kalhan S, Koletzko B, Macdonald I, Owen O, Uauy R. Report of the IDECG Working Group on lower and upper limits of carbohydrate and fat intake. Eur J Clin Nutr 1999;53:S177–8.
10. Koletzko B. Response to and range of acceptable fat intakes in infants and children. Eur J Clin Nutr 1999;53:S78–83.
11. Prentice AM, Paul AA. Fat and energy needs of children in developing countries. Am J Clin Nutr 2000;72:1253S–65S.
12. Vieu M-C, Traore T, Treche S. Effects of energy density and sweetness of gruels on Burkinabe infant energy intakes in free living conditions. Int J Food Sci Nutr 2001;52:213–8.
13. den Besten L, Glatthaar II, Ijsselmuiden CB. Adding alpha-amylase to weaning food to increase dietary intake in children. A randomized controlled trial. J Trop Pediatr 1998;44:4–9.
14. Bennett VA, Morales E, Gonzalez J, Peerson JM, Lopez de Romaña G, Brown KH. Effects of dietary viscosity and energy density on total daily energy consumption by young Peruvian children. Am J Clin Nutr 1999;70:285–91.
15. UK Department of Health, Committee on Medical Aspects of Food Policy, Working Group on the Weaning Diet. Weaning and the weaning diet. (Report on Health and Social Subjects, No. 45). London: Her Majesty's Stationery Office, 1994.
16. Kersting M, Alexy U, Sichert-Hellert W, Manz F, Schoch G. Measured consumption of commercial infant food products in German infants: results from the DONALD study. J Pediatr Gastroenterol Nutr 1998;27:547–52.
17. US Department of Agriculture, Agricultural Research Service. Continuing survey of food intake by individuals, 1994–96, 1998 (available on CD-ROM). Washington, DC: USDA, 2000.
18. Northstone K, Emmett P, Nethersole F, and the ALSPAC Study Team. The effect of age of introduction to lumpy solids on foods eaten and reported feeding difficulties at 6 and 15 months. J Hum Nutr Diet 2001;14:43–54.
19. UK Department of Health, Report on Health and Social Subjects. Dietary reference values for food energy and nutrients for the United Kingdom. London: Her Majesty's Stationery Office, 1991.
20. Dewey KG, Beaton G, Fjeld C, Lönnerdal B, Reeds P. Protein requirements of infants and children. Proceedings of the International Dietary Energy Consultative Group. Eur J Clin Nutr 1996;50:S119–47.
21. FAO/WHO. Requirements of vitamin A, iron, folate and vitamin B_{12}. Rome: Food and Agriculture Organization, 1988.
22. Institute of Medicine. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D and fluoride. Washington, DC: National Academy Press, 1997.
23. Institute of Medicine. Dietary reference intakes for thiamine, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, pantothenic acid, biotin, and choline. Washington, DC: National Academy Press, 1998.
24. Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academy Press, 2000.
25. Institute of Medicine. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press, 2001.
26. Joint FAO/WHO Expert Consultation. Vitamin and mineral requirements in human nutrition. Geneva: World Health Organization, 2002.
27. Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG. A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micro-nutrient status of Ghanaian infants from 6 to 12 months of age. Am J Clin Nutr 1999;70:391–404.
28. Brown KH, Santizo MC, Begin F, Torun B. Effect of supplementation with multiple micronutrients and/or bovine serum concentrate on the growth of low-income, peri-urban Guatemalan infants and young children. FASEB J 2000;14:A534.
29. Lopez de Romaña G, Brown KH, Black RE, Kanashiro HC. Longitudinal studies of infectious diseases and physical growth of infants in Huascar, an underprivileged peri-urban community of Lima, Peru. Am J Epidemiol 1989;129:769–84.
30. Creed de Kanashiro H, Brown KH, Lopez de Romaña G, Lopez T, Black RE. Consumption of food and nutrients by infants in Huascar (Lima), Peru. Am J Clin Nutr 1990;52:995–1004.

31. Heinig MJ, Nommsen LA, Peerson JM, Lonnerdal B, Dewey KG. Energy and protein intakes of breast-fed and formula-fed infants during the first year of life and their association with growth velocity: the DARLING Study. Am J Clin Nutr 1993;58:152–61.

32. Allen LH, Backstrand J, Stanek EJ, Chavez A, Pelto GH, Molina E, Mata A, Castillo J-B. The interactive effects of dietary quality on growth and attained size of young Mexican children. Am J Clin Nutr 1992;56:353–64.

33. Institute of Medicine. Nutrition during lactation. Washington, DC: National Academy Press, 1991.

34. Heiskanen K, Siimes MA, Salmenpera L, Perheentupa J. Low vitamin B$_6$ status associated with slow growth in healthy breast-fed infants. Pediatr Res 1995;38:740–6.

35. Coursin DB. Convulsive seizures in infants with pyridoxine-deficient diets. JAMA 1954;154:406–8.

36. Briend A, Darmon N. Determining limiting nutrients by linear programming: a new approach to predict insufficient intakes from complementary foods. Pediatrics 2000;106:1288–90.

37. Darmon N, Ferguson E, Briend A. Linear and non-linear programming to optimize the nutrient density of a population's diet: an example based on rural Malawian preschool diets. Am J Clin Nutr 2002;75:245–53.

38. Deshpande S, Peerson J, Brown KH, Kimmons JE, Dewey KG. Use of linear programming to evaluate nutrient gaps of complementary food diets in Bangladesh. FASEB J 2002 (CD ROM).

39. Gibson RS, Ferguson EL, Lehrfeld J. Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvement. Eur J Clin Nutr 1998;52:764–70.

40. De Pee S, West CE, Permaesih D, Martuti S, Muhilal, Hautvast JG. Orange fruit is more effective than are dark-green, leafy vegetables in increasing serum concentrations of retinol and β-carotene in schoolchildren in Indonesia. Am J Clin Nutr 1998;68:1058–67.

41. Weaver CM, Plawecki KL. Dietary calcium: adequacy of a vegetarian diet. Am J Clin Nutr 1994;59:1238S–41S.

42. Ziegler EE, Fomon SJ, Nelson SE, Rebouche CJ, Edwards BB, Rogers RR, Lehman LJ. Cow milk feeding in infancy: further observations on blood loss from the gastrointestinal tract. J Pediatr 1990;116:11–8.

43. Griffin IJ, Abrams SA. Iron and breastfeeding. Pediatr Clin North Am 2001;48:401–14.

44. Kimmons JE, Brown KH, Lartey A, Collison E, Mensah PPA, Dewey KG. The effects of fermentation and/or vacuum flask storage on the presence of coliforms in complementary foods prepared for Ghanaian children. Int J Food Sci Nutr 1990;50:195–201.

45. Underwood BA, Smitasiri S. Micronutrient malnutrition: policies and programmes for control and their implications. Annu Rev Nutr 1999;19:303–24.

46. Zlotkin S, Arthur P, Antwi KY, Yeung G. Randomized prospective controlled trial of ferrous sulfate drops versus microencapsulated ferrous fumarate "sprinkles" for treatment of anemia in Ghanaian infants and young children. FASEB J 2001;15:A635.

47. Briend A, Lacsala R, Prudhon C, Mounier B, Grellety Y, Golden MH. Ready-to-use therapeutic food for treatment of marasmus. Lancet 1999;353:1767–8.

48. Istituto Nazionale della Nutrizione. Strategies to fight anemia and growth retardation in Saharawi children.

Rome: Comitato Internazionale per lo Sviluppo dei Popoli, 1999.

49. Lutter CK. Macrolevel approaches to improve the availability of adequate complementary foods. Food Nutr Bull 2003;24:83–103.

50. Dewey KG. Nutrient composition of fortified complementary foods: Should age-specific micronutrient content and ration sizes be recommended? J Nutr (suppl), in press.

51. Brown KH, Dewey KG, Allen LH. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: World Health Organization, 1998.

52. Cohen RJ, Brown KH, Canahuati J, Rivera LL, Dewey KG. Effects of age of introduction of complementary foods on infant breast milk intake, total energy intake, and growth: a randomized intervention study in Honduras. Lancet 1994;344:288–93.

53. Dewey KG, Cohen RJ, Brown KH, Rivera LL. Age of introduction of complementary food and growth of term, low birth weight breastfed infants: a randomized intervention study in Honduras. Am J Clin Nutr 1999; 69:679–86.

54. Rivera J, Santizo MC, Hurtado E. Diseño y evaluación de un programa educativo para mejorar las prácticas de alimentación en niños de 6 a 24 meses de edad en comunidades rurales de Guatemala. (Design and evaluation of an educational programme to improve feeding practices of children 6 to 24 months of age in rural communities of Guatemala). Washington, DC: Organización Panamericana de la Salud, 1998.

55. Guptill KS, Esrey SA, Brown KH, Oni GA. Dietary impact of a home-prepared infant weaning food intervention in Kwara State, Nigeria. FASEB J 1990;4:A787.

56. Drewett R, Payman B, Whiteley S. Effect of complementary feeds on sucking and milk intake in breastfed babies: an experimental study. J Reprod Infant Psychol 1993;5:133–43.

57. Dewey KG. Approaches for improving complementary feeding of infants and young children. Geneva: World Health Organization, 2000.

58. Bhandari N, Bahl R, Nayyar B, Khokhar P, Rohde JE, Bhan MK. Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. J Nutr 2001;131:1946–51.

59. Brown KH, Peerson JM, Rivera J, Allen LH. Effect of supplemental zinc on the growth and serum zinc concentrations of pre-pubertal children: a meta-analysis of randomized, controlled trials. Am J Clin Nutr 2002;75: 1062–71.

60. WHO, Division of Child and Adolescent Health and Development. A critical link: interventions for physical growth and psychological development. (WHO/CHS/CAH/99.3). Geneva: World Health Organization, 1999.

61. Caulfield LE, Huffman SL, Piwoz EG. Interventions to improve intake of complementary foods by infants 6 to 12 months of age in developing countries: impact on growth and on the prevalence of malnutrition and potential contribution to child survival. Food Nutr Bull 1999;20:183–200.

62. Brown LV, Zeitlin MF, Peterson KE, Chowdhury AM, Rogers BL, Weld LH, Gershoff SN. Evaluation of the impact of weaning food messages on infant feeding

practices and child growth in rural Bangladesh. Am J Clin Nutr 1992;56:994–1003.

63. Guldan GS, Fan H-C, Ma X, Ni Z-Z, Xiang X, Tang M-Z. Culturally appropriate nutrition education improves infant feeding and growth in rural Sichuan, China. J Nutr 2000;130:1204–11.

64. McNelly B, Dunford C. Impact of Credit with Education on mothers' and their young children's nutrition: lower Pra rural bank Credit with Education program in Ghana (Research paper No. 4). Davis, Calif, USA: Freedom from Hunger, 1998.

65. Wollinka O, Keeley E, Burkhalter BR, Bashir N, eds. Hearth nutrition model: applications in Haiti, Vietnam and Bangladesh. Arlington, Va, USA: BASICS, 1997.

66. Burkhalter BR, Northurp RS. Hearth program at the Hôpital Albert Schweitzer in Haiti. In: Wollinka O, Keeley E, Burkhalter BR, Bashir N, eds. Hearth nutrition model: applications in Haiti, Vietnam and Bangladesh. Arlington, Va, USA: BASICS, 1997:13–42.

67. Sternin M, Sternin J, Marsh DL. Rapid, sustained childhood malnutrition alleviation through a positive-deviance approach in rural Vietnam: preliminary findings. In: Wollinka O, Keeley E, Burkhalter BR, Bashir N. Hearth nutrition model: applications in Haiti, Vietnam and Bangladesh. Arlington, Va, USA: BASICS, 1997:49–61.

68. Santos I, Victora CG, Martines J, Goncalves H, Gigante DP, Valle NJ, Pelto G. Nutrition counseling increases weight gain among Brazilian children. J Nutr 2001;131: 2866–73.

69. Dicken K, Griffiths M, Piwoz E. Designing by dialogue: a program planners' guide to consultative research for improving young child feeding. Washington, DC: Health and Human Resources Analysis for Africa Project, USAID, 1997.

70. Sternin M, Sternin J, Marsh D. Designing a community-based nutrition program using the Hearth Model and the positive deviance approach: a field guide. Westport, Conn, USA: Save the Children Foundation, 1999.

71. Klemm RDW, Puertollano EP, Villate EE. Nutrition communications to improve infant feeding: a planner's guide. Pasay City, Philippines: Helen Keller International, 1997.

72. Bhattacharyya K, Muarry J. Community assessment and planning for maternal and child health programs: a participatory approach in Ethiopia (Technical report). Arlington, Va, USA: BASICS, 1998.

73. Gillespie S. Supplementary feeding for women and young children: nutrition toolkit module no. 5 (World Bank Nutrition Toolkit). Washington, DC: World Bank, 1998.

74. WHO/London School of Hygiene and Tropical Medicine. Complementary feeding: family foods for breastfed children. (WHO/NHD/00.1; WHO/FCH /CAH/00.6) Geneva: World Health Organization, 2000.

75. Pan American Health Organization. Manual ProPAN (Proceso para la Promoción de la Alimentación del Niño). HPP/HPN/MCN/2002, Washington, DC: PAHO, 2002.

Promotion and advocacy for improved complementary feeding: Can we apply the lessons learned from breastfeeding?

Ellen G. Piwoz, Sandra L. Huffman, and Victoria J. Quinn

Abstract

Although many successes have been achieved in promoting breastfeeding, this has not been the case for complementary feeding. Some successes in promoting complementary feeding at the community level have been documented, but few of these efforts have expanded to a larger scale and become sustained. To discover the reasons for this difference, the key factors for the successful promotion of breastfeeding on a large scale were examined and compared with the efforts made in complementary feeding. These factors include definition and rationale, policy support, funding, advocacy, private-sector involvement, availability and use of monitoring data, integration of research into action, and the existence of a well-articulated series of steps for successful implementation. The lessons learned from the promotion of breastfeeding should be applied to complementary feeding, and the new Global Strategy for Infant and Young Child Feeding provides an excellent first step in this process.

Key words: Complementary feeding, breastfeeding, policy, advocacy

Introduction

Many programs showing improvements in complementary feeding have been reported throughout the developing world [1–6], and the elements that contributed to their success have been summarized [7, 8]. The LINKAGES Project of the Academy for Educational Development (AED) in Washington, DC, operating jointly with a number of African institutions and UNICEF, recently completed an assessment of the better practices associated with 10 successful community nutrition programs in Kenya, Tanzania, and Uganda [9]. Quinn [10] reported that successful behavioral-change communications programs had the following features:

» Helped in conducting national-level policy analysis, updating, and advocacy
» Included strategies and messages based on formative research
» Focused on a relatively small number of priority messages
» Used multiple channels to reach mothers and carers with messages through
– interpersonal communication
– community mobilization
– the local media (radio and print)
» Targeted fathers and grandmothers as well
» Emphasized "negotiation skills" in training that went beyond just passing the message
» Worked with women's groups
» Promoted a behavioral-change intervention package that
– was simplified and feasible
– was adaptable to different program contexts
– produced almost immediate results
– used skill-based training that was heavy on practice to ensure quick uptake by fieldworkers
– became a part of all preservice training for health, nutrition, and other relevant workers

After decades of experience, it seems that we know what to do at the community level to improve complementary feeding. The question is "Why have so few community efforts been able to expand to a larger scale and become sustained and successful national programs?"

To examine this question more carefully, we undertook a comparison of the global experience in promoting breastfeeding. The evidence suggests that breastfeeding promotion activities have been successful at the local level and have expanded nationally in most countries, and they appear to be sustained [11–13].

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Controlled trials have demonstrated the impact of home-based counseling on rates of exclusive breast-feeding [14, 15]. An excellent review of the evidence for the Ten Steps to Successful Breastfeeding initiative suggests that training in breastfeeding and lactation management, changes in maternity and postdelivery policies and practices, and continued support during the postnatal period have a dramatic impact on breast-feeding practices [16]. Demographic and Health Survey (DHS) data show an increase in exclusive breastfeeding rates over time in countries with active and well-resourced breastfeeding promotion programs and a decline in countries where breastfeeding promotion was not strong [17].

Comparisons of the different approaches used in breastfeeding promotion and support may help to highlight further actions that are needed to enhance complementary feeding. Analysis of these breastfeeding experiences has shown the following components to be particularly relevant: definition and rationale, policy support, funding, advocacy, private-sector (industry) involvement, availability and use of monitoring data, integration of research into action, and a well-articulated series of steps for successful implementation.

This paper describes the experience with breastfeeding promotion in each of these areas and compares it with efforts to improve complementary feeding in less-developed countries. This is not an exhaustive overview of all initiatives on infant and young child feeding worldwide, but focuses on published experiences and unpublished reports from primarily US-funded programs to which we had access. Recommendations for future action are also based on this comparison. This paper is intended to point out useful similarities and differences between these interrelated efforts and to stimulate new ideas for complementary feeding programs. The paper is not intended to be a comprehensive review of either breastfeeding or complementary feeding programs or practices.

Breastfeeding promotion programs

Definition and rationale

Until recently, when the dilemma of HIV transmission through breastfeeding became widely recognized, the definition of optimal breastfeeding was relatively simple and easy to measure. A clear set of optimal breastfeeding practices was defined by the World Health Organization (WHO) [18] and could be promoted (nearly) universally. These included behaviors of known (evidence-based) benefit, such as immediate breastfeeding initiation, exclusive breastfeeding, and continued breastfeeding for at least two years (box 1).

Today's breastfeeding definitions and indicators are relatively easy to understand and interpret by the gen-

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BOX 1. Recommended breastfeeding practices in the first six months

Initiate breastfeeding within one hour of birth
Establish good breastfeeding skills (proper positioning, attachment, and effective feeding)
Breastfeed exclusively for the first six months
Practice frequent, on-demand breastfeeding, including night feedings
Continue on-demand breastfeeding and introduce complementary foods beginning at six months of age
Continue breastfeeding for two years or longer

Adapted from refs. 6 and 7

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eral public, health workers, and policymakers. Data are collected regularly through Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), and other surveys and are reported in many annual documents (UNICEF's *State of the World's Children*, WHO's *World Health Report*, the World Bank's *World Development Report*, etc.).

Failure to follow the recommended breastfeeding practices has consequences that can be quantified in terms of increased morbidity, mortality, and fertility. The economic value of breastmilk has also been calculated [19, 20], and promotion of breastfeeding is seen as a highly cost-effective intervention. New recommendations for HIV-positive mothers [21] have complicated this relatively straightforward picture. What we know to be optimal breastfeeding is no longer universal in all populations, and changes in the indicators may become increasingly difficult to interpret. Nonetheless, for the better part of the last three decades, the health rationale behind the promotion of breastfeeding was so compelling that few people could argue with it.

The sizable benefit of breastfeeding in reducing fertility was a special advantage. It generated interest and support among demographers, reproductive health specialists, economists, and other experts concerned about child spacing, population growth, and their impact on development. The same is true for the environmental advantages of breastfeeding, though this benefit has been appreciated to a lesser extent.

Policy support

Many World Health Assembly resolutions, conferences, and policy statements provided strong policy support in favor of breastfeeding (box 2). The International Code of Marketing of Breast-Milk Substitutes was adopted by the World Health Assembly in 1981 [22] and has been further elaborated through subsequent resolutions several times since then. The Code has been effective in limiting direct marketing of infant formula to mothers who are served by the public health sector in countries throughout the world [11].

WHO and UNICEF provided the policy support that

BOX 2. International conventions, policy actions, and initiatives in support of breastfeeding

International Code of Marketing of Breast-Milk
  Substitutes (1981) and subsequent World Health
  Assembly resolutions
Convention on the Rights of the Child (1989)
World Summit for Children (1990)
World Declaration on the Survival, Protection, and
  Development of Children and Plan of Action for
  Children (1990)
Innocenti Declaration (1990)
Baby Friendly Hospital Initiative (1991)
International Nutrition Conference (1992)
International Conference on Population and
  Development (1994)
Fourth World Conference on Women (1995)
Global Strategy on Infant and Young Child Feeding
  (presented at the World Health Assembly in 2002)

led to worldwide acceptance of the need for breastfeeding programs. The Convention on the Rights of the Child (1989) brought together standards about rights of children in a single legal document. Standards related to childhood feeding contained in Article 26 included:

» To combat disease and malnutrition, including within the framework of primary health care, through, *inter alia*, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking water.
» To ensure that all segments of society, in particular parents and children, are informed, have access to education, and are supported in the use of basic knowledge of child health and nutrition, the advantages of breastfeeding, hygiene, and environmental sanitation, and the prevention of accidents.

The World Summit for Children in 1990 adopted a set of specific goals to be reached by the year 2000 to "ensure the survival, protection and development of children in the 1990s" [23]. The nations signing the resolution were committed to a 10-point program to protect the rights of children and to improve their lives. The points relating to child feeding were:

» We will work for optimal growth and development in childhood, through measures to eradicate hunger, malnutrition, and famine, and thus to relieve millions of children of tragic suffering in a world that has the means to feed all its citizens.
» We will work to strengthen the role and status of women. We will promote responsible planning of family size, child spacing, breastfeeding, and safe motherhood.

At the summit, a Plan of Action for Implementing the World Declaration on the Survival, Protection and Development of Children in the 1990s was written, which included the following statement relating to feeding of children: "For the young child…promo-

tion, protection and support of breastfeeding and complementary feeding practices, including frequent feeding."

Subsequently, specific goals were developed by the United Nations organizations, in conjunction with the World Bank and nongovernmental organizations, to monitor the progress in meeting the agenda of the World Summit and the Plan of Action (table 1) [24]. These plans were followed quickly by the Innocenti Declaration and the launch of the Baby Friendly Hospital Initiative (BFHI) [34, 35]. Throughout these stages, policy support was also provided by national governments (especially the Departments of Health) and health professional associations (medical, pediatric, and nursing).

It is apparent that a great deal of effort has gone into defining optimal breastfeeding practices and creating the knowledge base, policies, constituencies, capacity, and initiative to support efforts to promote and support these behaviors at many levels, particularly for exclusive breastfeeding. More recently, worldwide support for the promotion and protection of breastfeeding has been jeopardized by the risks of postnatal transmission by HIV-infected women, and the public controversy and confusion surrounding this issue. This controversy and confusion may reverse many of the advances in policy and practices observed in recent years [36].

Funding

Funding for breastfeeding has not been reliant on one sector only. For example, within one bilateral donor organization, USAID,* most support for international breastfeeding program efforts has come from the Population Division, because of the role of breastfeeding in reducing fertility. USAID's Health and Nutrition Divisions, regional bureaus, and country missions have also provided support, but often this support has been for integrated child survival programs in which breastfeeding was only one of several health interventions being promoted.

However, such integrated child survival support has been considerable. Since 1985, USAID's Office of Private and Voluntary Cooperation has worked with more than 35 private and voluntary organizations (PVOs) to carry out more than 335 child survival programs in 47 countries with the goal of providing high-quality, sustainable child survival interventions, including breastfeeding. As of 30 November 2000, these PVOs were currently supporting 72 projects, totaling $64,000,000 [37]. Breastfeeding was a component of many of these projects.

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* USAID is mentioned in this report specifically because the authors had access to resource allocation information from this bilateral donor. Requests for information from other sources were sent out, but responses were not available at the time this paper was submitted.

Advocacy

Many nongovernmental organizations (NGOs) have played a major role in maintaining governmental and international support for breastfeeding promotion. NGOs involved in breastfeeding are numerous, including international NGOs such as the Infant Baby Food Action Network (IBFAN), the La Leche League, Wellstart International, and the World Alliance for Breastfeeding Action (WABA).

Many country-level advocacy organizations played important roles in encouraging appropriate wording

TABLE 1. Goals for breastfeeding and complementary feeding, according to organization

Resolution/organization	Goal for breastfeeding	Goal for complementary feeding
International Conference of Nutrition/World Plan of Action (ICN) [25]	To reduce substantially the social and other impediments to optimal breastfeeding	None
World Summit on Children [24]	To empower all women to breastfeed their children exclusively for 4–6 months	To continue breastfeeding with complementary food into the second year of life
World Health Assembly [26]	To strengthen activities and develop new approaches to protect, promote, and support exclusive breastfeeding for 6 months	To improve complementary foods and feeding practices by ensuring sound and culture-specific nutrition counseling to mothers of young children, recommending the widest possible use of indigenous, nutrient-rich foodstuffs
IMCI [47]	"IMCI aims to reduce death, illness and disability, and to promote improved growth and development among children under 5 years of age."	
Care Initiative/UNICEF nutrition strategy [27]	To empower families, communities, and governments to improve the nutrition of women and children on the basis of adequate and sound analyses	
	Exclusive breastfeeding for about 6 months Initiation within first hour after birth Breastfeeding on demand Development of skills of breastmilk expression Protection from commercial pressures for artificial feeding	Timely introduction of complementary foods Breastfeeding into the second year Adequate complementary foods (energy and nutrient density, quantity) Frequent feeding
USAID [28]	Strategic objective: increased use of key child health and nutrition interventions	
LINKAGES [29]	Initiation of breastfeeding within 1 hour of birth Exclusive breastfeeding for the first 6 months of life Lactational amenorrhea method (LAM) acceptance rate (LAR) in women with infants less than 6 months old.	Country-specific objectives, but no general project objective
PVC Child survival grants program [30]	Support community-oriented child survival programs that measurably improve infant and child health and nutrition and that contribute to the reduction of infant and child mortality in countries throughout the world.	
	Exclusive breastfeeding of infants for about 6 months [28]	Appropriate complementary feeding from about 6 months of age, and continued breastfeeding until 24 months
Child Survival Collaborations and Resources Group (CORE) [30]	General goal to assist member organizations to reduce child and maternal mortality by improving the health of underserved populations	
BASICS [31]	Appropriate breastfeeding through at least 4 months	Appropriate child feeding (frequency, quantity, and quality of feeding)
Bangladesh [32]	To protect, promote, and support breastfeeding	None
Uganda [33]	To promote breastfeeding	None

in the international declarations mentioned previously and in encouraging their governments to pass legislation concerning the Code. These advocacy groups exist worldwide and, among many others, include the Breastfeeding Information Group (Kenya), the Society of Friends of Mother's Milk (Egypt), Fundación LACMAT (Argentina), PROALMA (Honduras), La Liga de la Leche (Guatemala), La Liga de la Leche Materna (Honduras), Asociación Hondureña de Lactancia Materna (AHLACMA), CALMA (El Salvador), the Breast Is Best League (Belize), the Ghana Association of Infant Feeding, the Breastfeeding Advocacy Group (Liberia), and the Nursing Mothers Association of the Philippines.

In addition to the nongovernmental advocacy groups, there exist many national breastfeeding commissions established by governments, with full-time coordinators, to bring together different organizations and branches of government working in breastfeeding-related programs. These commissions give a focus to breastfeeding efforts and create a means of working together to pool resources and technical expertise [38].

Many breastfeeding NGOs have operated in both advocacy and technical roles. They have been involved in promoting policy changes, training, improving hospital practices, restricting marketing of breastmilk substitutes (through boycotts, media, and revision of legislation), and direct support to mothers. They have been extremely influential in creating and maintaining momentum. The promotion and marketing of baby formula and related products by multinational corporations has also been a major stimulus for concerted action by breastfeeding advocacy organizations.

Private-sector (industry) involvement

The private sector has been involved with the breastfeeding agenda because of their production and marketing of breastmilk substitutes and follow-on foods, and their support for biomedical research on breastmilk and nutritional requirements of infants and children. As noted above, their actions have given the breastfeeding community a mission and focus to create urgency and galvanize support.

Other than this, few positive examples of private-sector support are available. Breastfeeding demands few marketable items (and those used, such as breast pumps, nursing pads, or publications on breastfeeding, seldom provide a large enough market to make industry collaboration a major support, except perhaps in the developed countries). Industry has thus been in competition with breastfeeding, because the marketing of breastmilk substitutes and feeding bottles, often in violation of the Code, interferes with breastfeeding promotion and support.

Availability and use of monitoring data

National-level data on breastfeeding, made available through the DHS, MICS, Centers for Disease Control and Prevention (CDC) surveys, as well as the WHO/NHD Global Data Bank, have been extremely important for monitoring the rates of breastfeeding and comparing the rates in countries throughout the world. As shown by Lutter [11] for Latin America and Grummer-Strawn [39] for parts of Africa, improvements in breastfeeding rates observed through national surveys appear to be real and not due to changes in the characteristics of the population.

Such data have been important to illustrate that breastfeeding promotion activities can be successful, and they have also been useful for advocacy purposes. The data allow program managers and policy makers to see where their country or region stands relative to others. Good performance gives an opportunity for positive feedback, whereas poor indicators have provided a call to action. Although there is one clear definition of optimal breastfeeding, several indicators are commonly used to measure "optimal breastfeeding practices," including initiation within one hour of birth, whether breastfeeding is exclusive, the duration of breastfeeding, etc. Several groups have compiled information on breastfeeding indicators and how to collect them [18, 24, 40, 41].

Integration of research into action

Breastfeeding research has addressed many different aspects, including immunological, biomedical, sociocultural, and operational issues. Researchers have had a tremendous impact on breastfeeding policies and programs. Many scientists have also been effective advocates, able to actively and widely disseminate research findings with clear messages on the next steps for policies and programs.

The most effective messages deal with the greatly increased risk of mortality in nonbreastfed infants in resource-poor settings; the increased risks of diarrhea, respiratory, and other infections with nonexclusive breastfeeding; the unique immunologic and growth-promoting properties of breastmilk; the contraceptive effects of breastfeeding; and the costs to hospitals and health systems of suboptimal breastfeeding practices. These messages are well known not only to the researchers themselves but also to all trained breastfeeding advocates.

Articulated steps for successful implementation

The breastfeeding agenda includes a well-articulated series of steps for successful implementation. The Ten Steps to Successful Breastfeeding were the foundation

of the WHO/UNICEF Baby Friendly Hospital Initiative (box 3). They give clear guidance on what needs to be done next to address a well-documented constraint to optimal breastfeeding, i.e., health-care practices [16]. The 10 steps are operational, and evidence has accumulated over time on their rationale, impact, and effect on breastfeeding.

Complementary feeding programs

With this short history and framework in mind, it is useful to consider the question "How does promotion of complementary feeding differ from breastfeeding promotion?" This is addressed below.

Definition and rationale

Unlike optimal breastfeeding, which has been defined in guidelines and can be measured relatively easily with several well-accepted indicators, the notion of "optimal complementary feeding"* has not, until recently, been clearly articulated. In fact, the very term "complementary feeding" is confusing in some settings where the terms "weaning foods" and "supplementary feeding" have long been part of the nutritional lexicon. To further add to this confusion, in some places the term "solid foods" is used interchangeably with "complementary feeding" [42].

The problem of lack of clarity does not apply only to developing countries. Even in industrialized countries, the guidelines and recommendations for complementary feeding are vague, not evidence-based, incomplete, and difficult to measure [43].

The health rationale for promoting improved complementary feeding is less compelling to the policy makers and the general public than those for breastfeeding. Because children receiving complementary feeding are older than infants and are less likely to die than infants (especially if they have been breastfed), the risks of inadequate complementary feeding as compared with adequate feeding are more subtle and certainly less recognizable. Most arguments in favor of programs to promote complementary feeding have been based on prevention of growth faltering and malnutrition, which until recently were not linked to other outcomes, such as increased risk of premature death [44]. Promotion of improved complementary feeding is similar to "promoting better diets" and not very enticing. Concepts of "small but healthy" were often debated in the literature and media, adding to the general lack of interest and of consistent messaging.

BOX 3. The ten steps to successful breastfeeding

Every facility providing maternity services and care for newborn infants should:
1. Have a written policy that is routinely communicated to all health-care staff
2. Train all health-care staff in skills necessary to implement this policy
3. Inform all pregnant women about the benefits and management of breastfeeding
4. Help mothers initiate breastfeeding within a half-hour of birth
5. Show mothers how to breastfeed, and how to maintain lactation even if they should be separated from their infants
6. Give newborn infants no food or drink other than breastmilk, unless medically indicated
7. Practice rooming-in, i.e., allowing mothers and infants to remain together 24 hours a day
8. Encourage breastfeeding on demand
9. Give no artificial teats or pacifiers to breastfeeding infants
10. Foster the establishment of breastfeeding support groups and refer mothers to them on discharge from the hospital or clinic

In 1998, WHO published a state-of-the-art, evidence-based review of complementary feeding, which provided an excellent, comprehensive analysis with reference to conditions in developing countries [2]. This review was later translated into key recommendations (box 4), but these recommendations have not yet been widely disseminated, and knowledge and capacity in this area are still limited within programs.*

Without a clear definition of optimal complementary feeding, it is difficult to obtain momentum and consistency across programs. This is evident in table 1, which shows the goals of different declarations and agencies for breastfeeding and complementary feeding programs.** Often there is a broad goal (to reduce malnutrition) and then more specific goals that address breastfeeding and complementary feeding. Not surprisingly, they differ widely.

Policy support

Nearly all of the policies and declarations given in the previous section included mention of child feeding beyond breastfeeding. However, this statement was

* In this paper the definition of optimal complementary feeding is taken from the WHO/UNICEF draft strategy [6]. It contains elements of timeliness, adequacy, safety, and appropriate feeding (responsiveness, frequency, and method of feeding) as defined on page 3 of the document.

* An exception to this is the Integrated Management of Childhood Illness (IMCI) strategy, which has been introduced in over 80 countries worldwide. IMCI includes, among other things, nutrition counseling and feeding guidance for case management by front-line health workers. The IMCI strategy and guidance were developed in 1995, prior to the state-of-the-art review.

** Agencies and governments often use different terms to represent what we consider to be goals, targets, or objectives, as distinguished from indicators, which are measurable.

BOX 4. WHO recommendations for complementary feeding

Give breastmilk alone for six months

Give complementary foods from six months onwards

If a child aged four through six months is not gaining weight adequately despite appropriate breastfeeding or receives frequent breastfeeds but appears hungry soon after, give complementary foods

When starting complementary foods, continue breastfeeding as often and as long as before

Give complementary foods that are rich in energy and nutrients, clean and safe, easy to prepare from family foods, and locally available and affordable

Give complementary foods three times daily to breastfed babies aged 6 to 7 months, increasing to five times daily by 12 months

Start with a few teaspoons and gradually increase the amount and variety

Actively encourage a child to eat

Make sure all utensils are clean

Spoon-feed foods from a cup or bowl

If foods are not refrigerated, feed them within two hours of preparation

During and after illness, breastfeed more frequently than usual and give extra meals

After illness, encourage a child to eat as much as possible at each meal, until the lost weight is regained.

Keep a chart of the child's weight

Based on refs. 6 and 45

typically general. For example, the World Summit for Children emphasized eradication of hunger and malnutrition, and although the Plan of Action was to be measured by several defined goals, there was no specific goal related to complementary feeding, except that it should be given in addition to continued breastfeeding into the second year of life.

Although the goals of international resolutions or agencies have been broad (reducing child mortality and morbidity) (table 1), breastfeeding has often been specifically mentioned. This has seldom been the case for complementary feeding, except for the Care Initiative, which was developed by the Nutrition Office at UNICEF. Individual projects have developed goals for complementary feeding, but unlike those for breastfeeding, these are not spelled out at the higher policy and administrative levels.

Funding

Because complementary feeding is usually conducted within integrated programs, it is difficult to obtain information on the funds expended. But as an example, the LINKAGES Project, which is managed at AED, was initially conceived of as a program to improve both breastfeeding and complementary feeding (as well as related maternal nutrition). Out of their funding of nearly $32,000,000 over five years, approximately 75% was spent on breastfeeding activities (including the lactational amenorrhea method, LAM), as compared with just 16% on complementary feeding (personal communication, Baker J, Academy for Educational Development, 2001). The reason, according to one policy maker at USAID: "I have not seen data or interventions on complementary feeding that have anything like the dramatic health impact of breastfeeding."

Advocacy

Advocacy in support of complementary feeding is less passionate and intensive than that for breastfeeding. National and international pediatric and dietetic associations have played a role in promoting guidelines for complementary feeding [43]. However, there are few, if any, advocacy groups whose primary goal is to make visible the problems associated with suboptimal complementary feeding (except as a part of general breastfeeding advocacy). Moreover, breastfeeding advocacy groups often have not included complementary feeding issues on their agenda.

In the United States, nutrition advocates generally belong to hunger-related organizations, and they support federal programs to increase food consumption among young children (as in the Women, Infants and Children's program). Such groups include the Center for Budget and Policy Priorities, the Food Research and Action Center, the Center for Science in the Public Interest, Public Voice, etc. International NGOs, such as Save the Children, CARE, OXFAM, and Catholic Relief Services, among others, advocate child survival, eradication of hunger, and emergency and famine relief. None of these organizations is considered an infant support organization, but they are seen as groups advocating broader nutrition, poverty reduction, or both in vulnerable populations.

Private-sector (industry) involvement

The role of the private sector in complementary feeding is potentially great—for example, to provide processed and fortified food products or premixes—but the food industry has been tainted by experience with infant formula marketing and by concerns about the affordability and sustainability of processed foods. Some of the industries that produce infant formula also produce and market baby foods. Some of these products (e.g., high-protein follow-on formulas) are of questionable nutritional benefit [46]. Concern has been raised that some industries encourage the use of complementary foods too early, thus impacting negatively on exclusive breastfeeding. Working with industry to improve complementary feeding has proven to be difficult for many breastfeeding advocates and program implementers.

Availability and use of monitoring data

Much time and attention has gone into the development, testing, and collection of indicators for monitoring breastfeeding patterns and practices. These indicators are clear and easily measured (table 2).

As a result of this concerted effort, several different organizations use similar questions to collect specific information on breastfeeding patterns. However, the same is not at present true for organizations collecting information on complementary feeding practices. In some cases, organizations only report the percentage

TABLE 2. Indicators for measuring breastfeeding and complementary feeding, according to organization

Resolution/organization	Indicators for breastfeeding	Indicators for complementary feeding
World Summit on Children [24]	Proportion of infants < 4 months (120 days) of age who are exclusively breastfed Proportion of children 20–23 months of age who are breastfeeding Proportion of infants 6–9 months (180–299 days) of age who are receiving breastmilk and complementary foods Proportion of all hospitals and maternity facilities that are baby friendly according to Baby Friendly Hospital Initiative (BFHI) criteria	Included in breastfeeding indicator: proportion of infants 6–9 months of age (180–299 days) who are receiving breastmilk and complementary foods
IMCI (WHO/UNICEF) [47]	*Health worker's practices* Proportion of children under 2 years of age whose carers are asked whether they breastfeed the child, whether the child takes any other food or fluids other than breastmilk, and whether the child's feeding has changed during illness. *Carer's practices* Proportion of children under 4 months of age who are exclusively breastfed	*Health worker's practices* Same as breastfeeding *Carer's practices* Proportion of children aged 6–9 months receiving breastmilk and complementary feeding

USAID PVO child survival projects [42]	Proportion of children who:
	    Were ever breastfed
	    Were breastfed during first hour after birth
	    Were fed colostrum (first milk) during first 3 days after birth
	    Were fed prelacteal feeds during first 3 days after birth
	    Are currently breastfed
	    Were breastfed for varying durations
		Proportion of children under 24 months of age who received different liquids and foods on the preceding day, including 10 specific items (meat, poultry, fish, shellfish, or eggs, fruit, vitamin A–containing vegetables, etc.)

Child Survival Collaborations and Resources Group (CORE) [48]	Proportion of children who were:
	    Ever breastfed
	    Breastfed for varying periods
		Proportion of children who were fed different foods, using a short list of liquids and foods given *the previous day;* foods included mashed, pureed, solid, or semisolid foods

Care Initiative/UNICEF nutrition strategy [39]	Proportion of children who were:
	    Ever breastfed
	    Exclusively breastfed for about the first 6 months of life
	    Breastfed into the second year of life
		Proportion of children who were:
		    Fed complementary foods by specific ages
		    Fed meals at different frequencies in the past 24 hours
		    Fed selected complementary foods of high nutrient density

BASICS [43]	Prevalence of appropriate breastfeeding through at least 4 months	Proportion of children who receive appropriate child feeding (frequency, quantity, and/or quality of feeding)
International Conference of Nutrition/World Plan of Action [36]	Proportion of infants less than 4 months old who are exclusively breastfeeding	—

of children receiving any food at all, whereas in other cases, very detailed information is gathered about the types of foods and liquids consumed during the previous day or week (table 3). This wealth of information could be used to advocate programs to improve complementary feeding—if guidance were given on how to analyze, interpret, and present it.

Integration of research into action

There is less evidence that research on complementary feeding has been integrated into action. In a PUBMED search for articles on complementary feeding published since 2000, 56 articles were found, and none was related to how programs can be encouraged to focus on improving complementary feeding in developing countries. Studies have focused on the nutritional composition and consistency of complementary foods, food hygiene, methods for reducing bacterial contamination, and cultural and behavioral issues. The findings have rarely, if ever, made headlines outside the nutrition community.

The lack of a clear definition of optimal complementary feeding that can be applied, albeit imperfectly, across diverse populations, combined with vague and insensitive indicators currently in use, has also hindered progress. The literature review, although groundbreaking and comprehensive, did not provide adequate guidance for immediate use by programs, although attempts have been made to include guidance in training activities (e.g., BASICS/UNICEF/WHO, 1999 [50]). Arguments to communicate the impact of suboptimal complementary feeding have not been summarized in a compelling way, to draw the attention of the general public and of policy makers.

Unlike the case for breastfeeding, the latest information and guidance on complementary feeding are not well known by nutritionists and other advocates in the field. Many programs still recommend "body-building foods, protective foods, and energy-providing foods" instead of giving specific messages about how to appropriately feed children aged 6 to 24 months, about how to create demand, and about negotiation skills and characteristics of successful programs [8, 10]. Three years after its publication, there is still a tremendous gap in knowledge and capacity on the issues covered in the literature review. However, WHO is developing and testing a training course on complementary

TABLE 3. Questions for measuring breastfeeding and complementary feeding, according to organization

Organization/survey	Questions	Note
Multiple indicator cluster surveys (MICS) [24] Similar questions are used in the rapid core assessment tool on child health (CATCH) used by the US PVO CORE Group.	Has (name of child) ever been breastfed? Is he/she still being breastfed? Since yesterday did he/she receive any of the following? Vitamins, mineral supplements, or medicine; plain water, sweetened flavored water, fruit juice, tea, or infusions; oral rehydration solutions (ORS); tinned, powdered, or fresh milk or infant formula; any other liquids (specify); solid or semisolid (mushy) food Received only breastmilk	The breastfeeding module (which is optional) contains these questions (required)
USAID PVC Child Survival Knowledge, Practices, and Coverage Survey [30]	Did you ever breastfeed (name of child)? How long after birth did you first put him/her to the breast? During the first three days after delivery, did you give him/her the liquid that came from your breasts? During the first three days after delivery, did you give him/her anything else to eat or drink before feeding breastmilk? Are you currently breastfeeding him/her? For how long did you breastfeed him/her? Did he/she eat any of the following foods *the previous day?* Any food made from grains? Pumpkin, red or yellow yams or squash, carrots, or red sweet potatoes? Any other food made from roots or tubers? Any green leafy vegetables? Mango, papaya (or other local vitamin A–rich fruits)? Any other fruits and vegetables? Meat, poultry, fish, shellfish, or eggs? Any foods made from legumes? Cheese or yogurt? Any food made with oil, fat, or butter? How many times did he/she eat semisolid (mashed or pureed) food on the previous day during the day or at night?	Food list is similar to that of DHS (below)

TABLE 3. Questions for measuring breastfeeding and complementary feeding, according to organization *(continued)*

| Demographic and Health Surveys (DHS) [49] | Did you ever breastfeed (name of child)?
  How long after birth did you first put him/her to the breast?
  Within the first three days after delivery, before your milk began flowing regularly, was he/she given anything to drink other than breastmilk?
  What was he/she given to drink before your milk began flowing regularly? Mark: milk (other than breastmilk), plain water, sugar or glucose water, gripe water, salt and sugar solution, fruit juice, infant formula, tea/infusions, honey, other (specify)
  Are you still breastfeeding him/her?
  For how many months did you breastfeed him/her?
  How many times did you breastfeed last night between sunset and sunrise?
  How many times did you breastfeed yesterday during the daylight hours?
  Did he/she drink anything from a bottle with a nipple yesterday or last night?
  Was sugar added to any of the foods or liquids he/she ate yesterday?
How many *times* did he/she eat solid, semisolid, or soft foods other than liquids yesterday during the day or at night?
How many *days* during the last seven days did he/she *drink* each of the following? (Then ask about yesterday)
  Mark: plain water; commercially produced infant formula; any other milk, such as tinned, powdered, or fresh animal milk; fruit juice; any other liquids, such as sugar water, tea, coffee, carbonated drinks, or soup broth
How many *days* during the last seven days did he/she eat each of the following *foods* either separately or combined with other food? (Then ask about yesterday)
  Any food made from grains (e.g., millet, sorghum, maize, rice, wheat, porridge, or other local grains)
  Pumpkin, red or yellow yams or squash, carrots, or red sweet potatoes
  Any other food made from roots or tubers (e.g., white potatoes, white yams, manioc, cassava, or other local roots/tubers)
  Any green leafy vegetables
  Mango, papaya (or other local vitamin A–rich fruits)
  Any other fruits and vegetables (e.g., bananas, apples/sauce, green beans, avocadoes, tomatoes)
  Meat, poultry, fish, shellfish, or eggs
  Any food made from legumes (e.g., lentils, beans, soybeans, pulses, or peanuts)
  Cheese or yogurt
  Any food made with oil, fat, or butter | This information is being collected in DHS Plus

Less detailed information was collected beginning in 1992 (with DHS III) |

feeding, which stands alone and is compatible with the IMCI, for groups specifically interested in complementary feeding. This training must be aggressively implemented in order to create a new understanding of the problems and possible solutions and to gather momentum for programs.

Articulated steps for successful implementation

To date, there is no clearly articulated agenda or set of operational steps for implementing programs to promote and support optimal complementary feeding practices. This may be due in part to the recognition that many constraints to optimal complementary feed-

ing exist within homes and communities, rather than within the health-care system. Nevertheless, a clear articulation of how to make complementary feeding operational—another set of steps—might facilitate broad implementation and scaling-up of programs.

How can lessons from breastfeeding be applied to complementary feeding programs?

We feel that there is an urgent need to come up with an operational definition of optimal complementary feeding and related practices that can be promoted

by programs worldwide. This will not be easy, but we believe it is possible. Once defined, there needs to be a set of measurable and sensitive indicators that can be used by programs to monitor progress, coupled with aggressive efforts to develop leadership and capacity within countries and organizations on this issue. Steps to successful complementary feeding should be clearly articulated based on available evidence.

Breastfeeding has been successful, in part, because it has a loyal following of dedicated advocates who believe strongly in its promotion, protection, and support. These advocates have been equipped with basic knowledge and skills and (until the HIV epidemic) a crystal-clear message. They have also stood up for the public health interest and worked toward measures to regulate and monitor practices of the powerful infant-feeding industry.

Successful advocacy will also require a much clearer articulation (and illustration) of the arguments in favor of support for programs to improve complementary feeding. We believe that there is evidence that programs, if properly designed, can improve the dietary practices and the nutritional status of young children. However, we must be much more convincing in terms of why these changes are important—looking at outcomes that will appeal to broad audiences and constituencies. Saving young children's lives is always appealing to international donors, but other benefits, such as education and economic development, must also be captured, as these appeal to local policy makers and decision makers [51].

There is growing interest in the role of the private sector in public health interventions, and the opportunity for collaboration is evident in processed foods for complementary feeding [52]. The private sector can be instrumental in encouraging policy initiatives within governments. Their advertising can help to expand the reach of messages disseminating the new definition of complementary feeding and create demand for improved practices. It is clearly feasible to work with such corporations without violating the Code of Marketing of Breast-Milk Substitutes [53], and the community working on complementary feeding needs to be sensitized and trained on how to establish partnerships and maintain productive collaboration with private industry.

The wealth of information currently being collected by DHS and PVO groups should be used as a powerful tool for advocacy and to inform programming. The questions about complementary feeding are detailed and time-consuming to administer, and unless we can establish their value for monitoring, evaluation, or advocacy, it is quite possible that they will be dropped from future surveys.

Analyses should be undertaken to assess the utility and validity of different candidate indicators. For example, existing DHS questions (table 3) can be used to develop indicators of dietary diversity, quality, and frequency—key elements of the definition of optimal complementary feeding:

» An indicator of *dietary diversity*, which could be reported across countries, might consist of the proportion of children over six months of age who consumed at least five different types of food (grains, tubers, fruits, vegetables, meat/fish/poultry/eggs, legumes, or dairy products) in addition to breastmilk.
» An indicator of *diet quality* might consist of the proportion of children over six months old who consumed animal products in addition to breastmilk. Another indicator could be the proportion of children consuming any food rich in vitamin A.
» An indicator of *feeding frequency* (the number of meals and snacks per day) could be the proportion of children aged 6 to 11 months who consumed solid or semisolid foods at least three times per day in addition to breastmilk, and those aged 12 months and older who consumed solid foods at least five times per day.

These and other possible indicators should be evaluated to see which has the greatest value in describing progress toward achieving optimal complementary feeding. For example, recent analyses of the DHS in five Latin American countries illustrate that the feeding frequency (the number of meals and snacks per day) could be a useful indicator. Ruel and Menon [54] found that between 5% and 53% of children 6 to 9 months of age and between 4% and 15% of children 12 to 18 months of age did not consume at least three meals or snacks during the 24 hours preceding the survey. Between 25% and 77% of children 12 to 18 months old did not consume the recommended minimum of five meals or snacks per day (table 4).

In Ethiopia, the mean frequency of meals and snacks consumed per day increased progressively during early childhood, from an average of 0.6 per day for infants 6 to 8 months of age to 1.6, 2.4, 3.0, and 3.4 per day for children aged 9 to 11, 12 to 17, 18 to 23, and 24 to 35 months, respectively (personal communication, Ruel

TABLE 4. Number of meals/snacks consumed in the previous 24 hours (DHS studies), according to age[a]

Country	6–9 mo	12–18 mo	
	% consuming < 3 meals or snacks/day	% consuming < 3 meals or snacks/day	% consuming < 5 meals or snacks/day
Bolivia (1998)	32	10	60
Colombia (1995)	5	4	25
Guatemala (1995)	45	13	77
Nicaragua (1998)	22	11	65
Peru (1996)	53	15	73

a. Source: ref. 54.

MT, Arimond M, International Food Policy Research Institute, 2001).

We also used data available from the DHS website (www.macroint.com/dhs/) and published reports to examine a possible indicator based on consumption of animal products. Our rapid analysis uses food consumption data for children aged 16 to 19 months in order to compare breastfeeding and nonbreastfeeding children. The results of this analysis, shown in table 5 and figures 1 and 2, are intended to illustrate the possibilities only. The analysis is constrained by the way the data are currently reported, yet it suggests that such an indicator might be useful.

One hopeful outcome of this consultation is a decision to look closely at the DHS to determine appropriate and valid indicators for program monitoring and advocacy and to suggest new questions to capture aspects of optimal complementary feeding that are not currently being measured (e.g., responsiveness to child signals and safe preparation). Work is currently being carried out to validate indicators of child feeding and care and of diet diversity, which could be built upon [66].

TABLE 5. Nutritional status of children aged 12 to 23 months and consumption of animal products[a]

Country	Year	% <–2SD weight-for-height	% <–2SD height-for-age	Consumption of animal products (age in mo)	% consuming animal products in preceding 24 h		Definition of animal products
					BF	Not BF	
Bangladesh	1999–2000	20	52	16–19	47	55	Meat, fish, eggs
Egypt	2000	3	24	16–17	48	56	Fish, eggs, poultry
Ethiopia	2000	20	57	16–17	13	6	Meat, fish, eggs, cheese, yogurt
Gabon	2000	3	24	16–17	76	77	Meat, fish, eggs
Haiti	2000	8	31	16–19	36	54	Meat, poultry, fish, eggs
Kazakhstan	1999	3	17	12–23	67	70	Meat, poultry, eggs
Kenya	1998	5	38	16–17 BF 12–17 Not BF	56	63	Meat, poultry, fish, eggs
Kyrgyz Republic	1997	6	34	12–23 BF 24–29 Not BF	64	72	Meat, poultry, fish, eggs
Malawi	2000	13 (12–15 mo)	47 (12–15 mo)	16–17 BF 18–23 Not BF	42	47	Meat, poultry, fish, eggs
Nigeria	1999	16	55	16–17	49	NA	Meat, poultry, fish, eggs
Zimbabwe	1999	10	37	16-17	43	NA	Meat, poultry, fish, eggs

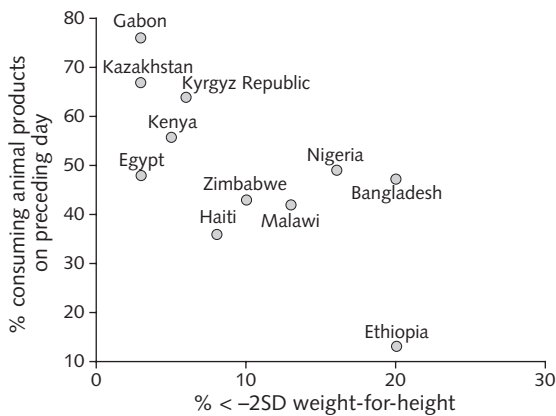a. BF, Breastfed. Sources: refs. 55–65.

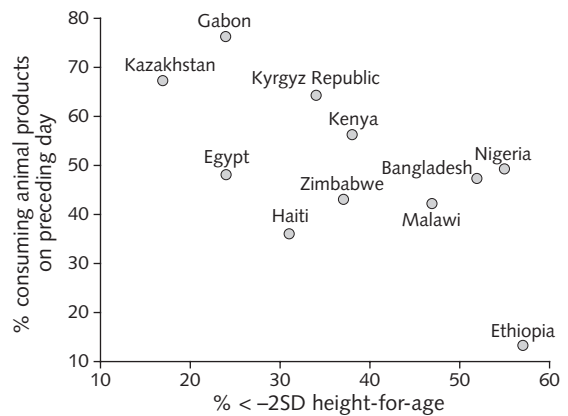FIG 1. Relationship of consumption of animal products and weight-for-height

FIG. 2. Relationship of consumption of animal products and height-for-age

Another hopeful outcome of this consultation is the development of a set of steps for successful complementary feeding. This would require consensus about key issues on policy, training, types of programs, and contact points, as well as recommended practices. The latter will probably require local adaptation, but general guidance is already available for how this can be undertaken (e.g., Dickin et al. [67]). One approach may be to adapt the Ten Steps to Successful Breastfeeding (box 5). The many papers presented at this consultation are likely to provide the best evidence for formulating these steps.

The dilemma of HIV and breastfeeding may, ironically, provide added impetus to strengthen complementary feeding programs. It has become increasingly clear that complete avoidance of breastfeeding by HIV-positive mothers is an unrealistic expectation in many settings, particularly in Africa, where the prevalence of HIV is greatest [68–70]. WHO [21] currently recommends exclusive breastfeeding for all HIV-positive women who are informed of the risks and alternatives and choose to breastfeed. These women are advised to discontinue breastfeeding "as soon as feasible, taking into account local circumstances, the individual woman's situation, and the risks of replacement feeding (including infections other than HIV and malnutrition)" [21, page 8]. Thus, in many settings, there will be HIV-infected women seeking advice and support on how to feed their infants after they stop breastfeeding. Programs must be prepared to give this advice and support. This will require that health workers better understand the recommended practices for all children after the age of six months, with children of HIV-positive women comprising a special case that needs tailored advice [71]. The complementary feeding community should seize the opportunity tragically presented by this dilemma to improve the capacity of programs to address the needs of children beyond the period of exclusive breastfeeding.

Conclusions

The movement to promote, support, and protect breastfeeding has a long and wide history. Members of this movement come from a range of disciplines and have developed a clear and comprehensive agenda composed of upstream and downstream initiatives and activities to achieve its goals.

The upstream activities include legal reforms, formation of international advocacy groups, and reform of hospital policies. Moving more downstream are efforts to build capacity worldwide—the training of hundreds of lactation management specialists and breastfeeding counselors through Wellstart International, the Institute of Child Health/UK training program, the WHO Breastfeeding Counselling training course [72], and national spin-offs. They have used the mass media to promote their messages, and at the most downstream level they have engaged in the formation of mother-to-mother support groups.

The movement has a wide range of supporters, drawn to it because breastfeeding is truly a natural wonder. Immunologists are interested because of the unique properties of breastmilk, which are unparalleled in any natural substitute. The medical profession is interested because breastmilk is life-giving and health-giving for newborn infants. Nutritionists are behind it because breastmilk is the most nutritious food for babies, providing energy, protein, and essential vitamins, fats, and minerals for growth and development. Population advocates support it because of its role in birth spacing. Child development specialists support breastfeeding because of the important bonding and attachment it provides to mother and baby, which are integral components of cognitive and psychosocial development. Indeed, if you asked any group of women worldwide what comes to mind when we say the word breastfeeding, you might get responses such as motherhood, nature, something given from God, or life itself. Breastfeeding provides clear and quantifiable benefits to mothers, infants, and society. The cost of breastfeeding is borne only by the mother.

Complementary feeding does not have any of these hallmarks. Our programs and emphases until now

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BOX 5. Should there be "Ten Steps to Successful Complementary Feeding"?

Every facility and community program providing care for children aged 6 to 24 months should:

1. Have a written policy that is communicated to all health-care staff about complementary feeding
2. Develop local feeding guidelines based on formative research
3. Train all health-care and community workers in skills necessary to implement the policy and guidelines
4. Inform all carers and parents about the benefits and management of complementary feeding
5. Help mothers initiate complementary feeding at six months.
6. Show mothers how to safely prepare and offer complementary foods, while maintaining and supporting breastfeeding, according to the age and circumstances of the child.
7. Teach mothers about feeding frequency, food variety, and adequate quantities for growing children
8. Counsel mothers how to maintain adequate complementary feeding during and following illness and loss of appetite.
9. Establish infant feeding and care support groups and refer mothers to them
10. Refer all children who are malnourished, sick, or living in families with special circumstances to health-care and available family support services

have been relatively narrow and downstream. We have focused a great deal of intellectual energy on debates about the individual nutrients, quality versus quantity, the appropriate age of introduction, and the impact of feeding on breastmilk intake, while programs stress food groups and not changes in practices. Complementary feeding has been primarily the realm of the nutrition community; it has not drawn support from the same range of disciplines supporting breastfeeding.

Complementary feeding is often perceived to be a problem of poverty and limited access to food. It is a family responsibility, not something provided only by the mother for free. It has no natural advocates, no advocacy groups, and no movement to support it. It is bound up with all the other big problems and challenges of development.

We need to reshape our views on complementary feeding. We must define it for programs, find ways to measure and monitor progress, build capacity for implementation, form advocacy groups to create demand for action, expand constituencies, link research directly to programs, engage the private sector constructively, and take advantage of opportunities that arise to enhance funding and the profile of this important work in the community. The new Global Strategy for Infant and Young Child Feeding [6] is an excellent first step in this process. However, it must be shared and implemented with enthusiasm and conviction. Otherwise it will lose prominence and be set aside as other more visible and urgent health and development problems capture the attention of policy makers and their limited human and financial resources.

References

1. Dewey KG. Approaches for improving complementary feeding of infants and young children. WHO Consultation on Infant Feeding and Young Child Feeding. Geneva: WHO, 2000.
2. Brown K, Dewey K, Allen L. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: WHO, 1998.
3. Ross J. Cost-effectiveness of the nutrition communications project in Mali. SARA Project. Washington, DC: Academy for Educational Development, 1997.
4. Piwoz EG. Improving infant feeding practices during childhood illness and convalescence: lessons learned in Africa. Washington, DC: Academy for Educational Development, May 1994.
5. Griffiths M. The weaning project: improving young child feeding practices in Indonesia: project overview. Washington, DC: Manoff Group, 1991.
6. WHO/UNICEF. Global strategy for infant and young child feeding. Geneva: World Health Organization, 2001.
7. LINKAGES and SARA Projects. Facts for feeding: recommended practices to improve infant nutrition in the first 6 months. Washington, DC: Academy for Educational Development, January 1999.
8. Caulfield LE, Huffman SL, Piwoz EG. Interventions to improve complementary food intakes of 6–12-month-old infants in developing countries: impact on growth, prevalence of malnutrition, and potential contribution to child survival. Food Nutr Bull 1999;20:183–200.
9. Iannotti L, Gillespie S. Community nutrition programming: lessons learned and experiences from Kenya, Tanzania, and Uganda. The LINKAGES Project. Washington, DC: Academy for Educational Development, 2001.
10. Quinn V. Behavior change communications to improve infant feeding practices: recent news from large-scale programs in Bolivia, Ghana, and Madagascar. Vienna: International Congress on Nutrition, August 2001 (abstract).
11. Lutter CK. Breastfeeding promotion: Is its effectiveness supported by scientific evidence and global changes in breastfeeding behaviors? In: Koletzko B, Hernall O, Michaelsen K, eds. Short and long term effects of breast feeding on child health. New York: Kluwer Academic/Plenum Publishers, 2000:355–68.
12. Green C. Improving breastfeeding behaviors: evidence from two decades of intervention research. The LINK-AGES Project. Washington, DC: Academy for Educational Development, 1999.
13. UNICEF. Breastfeeding for a healthy future. New York: UNICEF, 1999.
14. Haider R, Ashworth A, Kabir I, Huttly SR. Effect of community-based peer counsellors on exclusive breastfeeding practices in Dhaka, Bangladesh: a randomised controlled trial. Lancet 2000;356:1643–7.
15. Morrow AL, Guerrero ML, Shults J, Calva JJ, Lutter C, Bravo J, Luiz-Palacios G, Morrow RC, Butterfoss FD. Efficacy of home-based peer counseling to promote exclusive breastfeeding: a randomised controlled trial. Lancet 1999;353:1226–31.
16. WHO. Evidence for the ten steps to successful breastfeeding. Geneva: Division of Child Health and Development, World Health Organization, 1998.
17. Rutstein S. Impact of breastfeeding promotion: analysis of DHS data (mimeo). Calverton, Md, USA: Macro International, 28 July 2000.
18. WHO. Indicators for assessing breastfeeding practices. WHO/CDD/SER/91.14. Geneva: World Health Organization, 1991.
19. Aguayo VM, Ross JS. The monetary value of human milk in Francophone West Africa. A PROFILES analysis for nutrition policy communication. Food Nutr Bull 2002; 23:153–61.
20. Huffman SL, Yeager BA, Levine R, Shelton J, Labbok M. Breastfeeding saves lives: an estimate of the impact of breastfeeding on infant mortality in developing countries. Bethesda, Md, USA: Nurture Center to Prevent Childhood Malnutrition, June 1991.
21. WHO. New data on the prevention of mother-to-child transmission of HIV and their policy implications: conclusions and recommendations. WHO Technical Consultation on behalf of the UNFPA/UNICEF/WHO/UNAIDS Inter-Agency Task Team on Mother-to-Child Transmission of HIV. Geneva: World Health Organization, October 2000.

22. WHO. The international code of marketing of breast-milk substitutes. Geneva: World Health Organization, 1981.

23. UNICEF. World summit on children. New York: UNICEF, 2001. http://unicef.org/wsc/goals.htm/nutrition.

24. UNICEF. Monitoring progress toward the goals of the world summit for children. A practical handbook for multiple-indicator surveys. New York: UNICEF, 1995.

25. WHO Nutrition Programme. Highlights of recent activities in the context of the World Declaration and Plan of Action for Nutrition, December 1995. Geneva: World Health Organization, 1995.

26. World Health Assembly. Infant and young child nutrition. Agenda item 13.1, WHA54.2, 8 May 2001. Geneva: World Health Organization, 2001.

27. Engle P, Llotska L, Armstrong H. The care initiative: assessment, analysis and action to improve care for nutrition. New York: UNICEF, 1997.

28. USAID. Bureau for global programs, field support and research. Center for Population Health and Nutrition. Strategic plan. Washington, DC: USAID, January 1999.

29. LINKAGES. Revised Program Submission. Washington, DC: Academy for Educational Development, 2001.

30. USAID. PVC Child Survival Program. Washington, DC: USAID, 2000.

31. BASICS. Strategic objectives. Arlington, Va, USA: BASICS, 2001.

32. Institute of Nutrition and Food Science, Department of Economics, University of Dhaka, and Dhaka Urban Community Health Programme. Strategies for Bangladesh (unpublished document). Manila: Asian Development Bank, February 1998.

33. Bachou H. The nutrition situation in Uganda. South Africa J Clin Nutr 2000;13(3).

34. WHO. Protection, promotion, and supporting breast-feeding: the special role of maternity services. Geneva: World Health Organization, 1989.

35. WHO. Baby Friendly Hospital Initiative. Geneva: World Health Organization, 1992.

36. Latham M, Preble EA. Appropriate feeding methods for infants of HIV-infected mothers in sub-Saharan Africa. BMJ 2000;320:1656–60.

37. USAID. Technical reference materials for USAID PVC Child Survival Programs. Washington, DC: USAID, 2000.

38. Huffman SL. Breastfeeding policies in the US: What can we learn from developing countries? In: Picciano M, Lonnerdal B, eds. Mechanisms regulating lactation and infant nutrient utilization. New York: John Wiley & Sons, 1992:147–67.

39. Grummer-Strawn LM. The effect of changes in population characteristics on breastfeeding trends in fifteen developing countries. Int J Epidemiol 1996;25:94–102.

40. Lung'aho MS, Huffman SL, Labbok MH, Sommerfelt E, Baker J. Toolkit for monitoring and evaluating breastfeeding practices and programs. Washington, DC: Wellstart International Expanded Promotion of Breastfeeding Program (EPB), September 1996.

41. Tsui A. Reproductive health indicators breastfeeding. New Orleans, La, USA: Tulane University/Family Health International, 1995.

42. Anderson AS, Guthrie C, Alder EM, Forsythe S, Howie PW, Williams FLR. Rattling the place: reasons and ration-ales for early weaning. Health Educ Res 2001;16:471–9.

43. Zlotkin SL. Present-day policies, practice and problems: Canadian recommendations. In: Research priorities in complementary feeding: IPA and ESPGHAN Workshop. Pediatrics 2000;106(5 suppl):1272–3.

44. Pelletier DL. The relationship between child anthropometry and mortality in developing countries: implications for policy, programs, and future research. J Nutr 1994;124(10 suppl):2074S–81S.

45. WHO. Complementary feeding: family foods for breastfed children. Geneva: Department of Nutrition for Health and Development and Department of Child and Adolescent Health and Development, World Health Organization, 2000.

46. Dewey KG. Protein and amino acids. In: Research priorities in complementary feeding: IPA and ESPGHAN Workshop Proceedings. Pediatrics 2000;106:1292.

47. WHO. IMCI indicators, monitoring and evaluation. IMCI information. Geneva: World Health Organization, 1999. http://www.who.int/child-adolescent-health

48. CORE. Rapid core assessment tool on child health (CATCH). October 2000. From Macro website:

49. Macro International. DHS indicators. Calverton, Md, USA: Macro International, 2001.

50. BASICS/UNICEF/WHO. Nutrition essentials: a guide for health managers. Arlington, Va, USA: BASICS/USAID, 1999.

51. Burkhalter BR, Abel E, Aguayo V, Diene SM, Parloto MB, Ross JS. Nutrition advocacy and national development: the Profiles programme and its application. Bull WHO 1999;77:407–15.

52. Lutter CK. Processed complementary foods: summary of nutritional characteristics, methods of production and distribution, and costs. Food Nutr Bull 1999;20:211–4.

53. Clark D, Shrimpton R. Complementary feeding, the Code and Codex. Food Nutr Bull 2000;21:25–9.

54. Ruel MT, Menon P. Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. J Nutr 2002;132:1180–7.

55. Macro International. Bangladesh demographic and health survey. Calverton, Md, USA: Macro International, 1999–2000.

56. Macro International. Egypt demographic and health survey. Calverton, Md, USA: Macro International, 2000.

57. Macro International. Ethiopia demographic and health survey. Calverton, Md, USA: Macro International, 2000.

58. Macro International. Gabon demographic and health survey. Calverton, Md, USA: Macro International, 2000.

59. Macro International. Haiti demographic and health survey. Calverton, Md, USA: Macro International, 2000.

60. Macro International. Kazakhstan demographic and health survey. Calverton, Md, USA: Macro International, 1999.

61. Macro International. Kenya demographic and health survey. Calverton, Md, USA: Macro International, 1998.

62. Macro International. Kyrgyz Republic demographic and health survey. Calverton, Md, USA: Macro International, 1997.

63. Macro International. Nigeria demographic and health survey. Calverton, Md, USA: Macro International, 1999.

64. Macro International. Malawi demographic and health survey. Calverton, Md, USA: Macro International, 2000.

65. Macro International. Zimbabwe demographic and health survey. Calverton, Md, USA: Macro International, 1999.

66. Arimond M, Ruel M. Assessing care: progress toward the measurement of selected care and child feeding practices, and implications for programs. FCND Discussion Paper No. 19. Washington, DC: International Food Policy Research Institute, 2001.

67. Dickin K, Griffiths M, Piwoz EG. Designing by dialogue: consultative research to improve young child feeding. The SARA project. Washington, DC: Academy for Educational Development, 1997.

68. Humphrey J, Iliff P. Is breast not best? Feeding babies born to HIV-positive mothers: Bringing balance to a complex issue. Nutr Rev 2001;59(4):119–27.

69. Guay L, Ruff A. HIV and infant feeding: an ongoing challenge. JAMA 2001;286:2462–4.

70. Preble EA, Piwoz EG. Prevention of mother-to-child transmission of HIV in Africa: practical guidance for programs. Washington, DC: Academy for Educational Development, 2001.

71. Piwoz EG, Huffman SL, Lusk D, Zehner E, O'Gara C. Issues, risks, and challenges of early breastfeeding cessation as an option for reducing postnatal transmission of HIV in Africa. Washington, DC: Academy for Educational Development, 2001.

72. WHO. Breastfeeding counselling: a training course. WHO/CDR/93.4. Geneva: World Health Organization, 1993.

Improving feeding practices: Current patterns, common constraints, and the design of interventions

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Abstract

We propose a set of "best-practice complementary feeding behaviors," which were derived by combining principles of psychosocial care with current knowledge in nutritional sciences. We provide a theoretical rationale for assessing and describing complementary feeding practices in terms of what *is fed,* how *food is prepared and given,* who *feeds the child,* when *food is fed (frequency and scheduling), and the feeding environment (*where*). We also discuss the significance of selected sociocultural determinants of these practices for the design of interventions. We then review 18 case studies in relation to these practices and their determinants. The exercise, in which we abstracted data from ethnographic reports, revealed areas of congruence and deviations from best-practice behaviors. The data on feeding practices are described with a common framework to facilitate comparison across sites. Key themes emerging from the studies include the significance of the larger family, the effects of competing maternal time demands, and the importance of parental perceptions and cultural constructs in affecting complementary feeding practices. Finally, we discuss the implications of the findings for future interventions.*

Key words: Care: women's roles and infant feeding; determinants of feeding practices; feeding styles

Part 1. Introduction and background

Introduction

The nutritional care of the young is a major challenge for many animal species, and humans are no exception.

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From the time the umbilical cord is cut to the point at which the child can obtain all of its nutritional requirements from an adequate share of the household diet is a difficult period for caregivers, regardless of their level of household food security. The activities that occur during this period consist of multiple behavioral and physiological events. The totality of these events constitutes the weaning process, in which the young child moves from total nutritional dependence on his or her mother to relative independence.

Among mammals, the solution to the challenge of feeding new offspring is maternal milk, which is augmented at some stage of their development with other foods. In contemporary nutritional parlance, these other foods are referred to as "complementary foods," which carries the implication that their function is to augment the nutrients received from maternal milk. When the offspring are no longer receiving any maternal milk, it is common practice to refer them as weaned. To avoid confusion between the larger weaning process and the specific behaviors that are involved in the total cessation of breastfeeding, we will use the term "sevrage" (from the French word for weaning) for the latter.

The mechanisms for delivering complementary foods to dependent offspring and the forms in which such foods are provided vary from one species to another and depend on a number of factors, including the degree of physiological maturity and the methods of protecting the young from predators. Throughout the course of our sociocultural evolution from a hunting-gathering lifestyle to industrial societies, premastication of vegetable and animal foods has been a primary technique for humans. This technique has continued into modern times (see case studies in the Appendix). In addition to techniques that permit parents to feed family foods to infants and young children, another strategy to provide complementary foods is the creation of special transitional foods [1].

This paper examines the behavioral aspects of complementary feeding. The aim is to assist the process of

planning interventions to improve feeding practices during the period before children can meet their nutritional requirements from the household diet. In exclusively breastfed infants, this will typically be the period from the age of 6 months to about 24 to 30 months.

Background

Growth faltering as a marker of inadequate nutrition

The presentation of a child's growth as a smooth line that rises steeply in early childhood, then more slowly until adolescence when there is another sharp rise, after which it flattens as adult height is reached, is, to some extent, a convention of the time units of data presentation. The more frequently measurements are made, the easier it is to see the unevenness in growth in a healthy, well-growing child. But in healthy children whose growth is not constrained by an inadequate nutrient intake or illness, the periods of no apparent growth are very short. As a result, the calculated growth rate for a population of well-growing children shows that a steady increment in size is the normal condition when growth is not constrained by exogenous factors. It is the nature of young children to grow and develop rapidly and steadily. When they are not, something is wrong.

A large body of anthropometric data, accumulated over the past several decades, shows the existence of significant constraints to normal growth that have affected millions of children, almost entirely in the developing countries. Anthropometric data also provide evidence of when children in different populations are most likely to be affected by these constraints. Regardless of how protracted or short the period of risk is, in virtually all populations in which growth is constrained the period of greatest vulnerability is the second semester of life (6 to 12 months of age) and well into the second year (until 18 months of age and often longer). It begins when maternal milk is no longer adequate to supply all of the child's needs and continues until he or she is able to meet the nutritional requirements through consumption of the usual family diet and requires no special assistance with eating.

The anthropometric evidence of growth faltering has fueled an international research effort that has been aimed mainly at understanding its biological determinants. Epidemiological and social research has also been directed to this problem, although less extensively. At the same time, evaluations of programs to prevent or ameliorate faltering have contributed further knowledge about this pervasive public health problem [2, 3]. It is important to note, at the outset, that much of the research activity has been directed to the wide age spectrum in which anthropometric data provide evidence of undernutrition, typically from zero to five years of age. Consequently, an understanding of the determinants during the rapidly changing condi-

tions of infancy and early childhood is much more difficult to acquire.

Changing perspectives on the determinants of growth faltering

Program activities, whether conducted by national governments, nongovernmental organizations, or international agencies, reflect changing perspectives on the modifiable determinants of nutritional status. For example, earlier foci in nutrition interventions for children have emphasized improving the quality of food and diet, improving the household food supply, engaging in educational activities to provide information on appropriate foods, and education on hygienic food preparation. Within these general rubrics one can trace an evolution of thinking, which is evident in the changing emphases on specific elements. For example, with respect to food quality, there was an initial focus on the overall adequacy of the diet, which shifted to a concern with protein quality, followed by another shift to emphasize the adequacy of energy intake.

In recent years, additional foci of concern have been identified that are a consequence of the continuing coevolution of research and action to prevent growth faltering and undernutrition. These newly emerging concerns do not, for the most part, replace earlier ones, but they tend to shift the emphasis on different aspects of infant and young child nutrition. The shift from a primary concern with macronutrients to a focus on micronutrients is readily apparent from an examination of current research topics. It is also rapidly becoming a central focus of programs. Recognition of the importance of intrahousehold food distribution is another area of emphasis and may be affecting the programming in various ways. For example, today many supplementary feeding programs provide food to other household members and appear to be less concerned about leakage. This development may reflect a tacit recognition on the part of programs that, regardless of biological vulnerability, the most needy family members may not receive sufficient quantities of the supplement unless longstanding patterns of intrahousehold distribution of food resources are honored.

One of the most significant changes in approaches to identifying and intervening on modifiable determinants is the expanding concern with the behavioral aspects of infant and young child feeding. A primary aim of this paper is to examine the implications of this focus for how we conceptualize, study, and intervene to improve infant and young child feeding practices.

The role of the caregiver's behavior as a primary determinant of nutrition

Historical developments

Historically, there has been a longstanding but poorly coordinated interest in how the behavior of the care-

giver affects nutrition. Prior to 1990, when the concept of "care" was given formal recognition in the UNICEF conceptual framework (see below), there were sporadic efforts to provide empirical data linking the caregiver's behavior to nutritional outcomes. For example, in the early 1970s Muñoz de Chávez et al. attempted to identify specific behaviors that protected children from malnutrition in a Mexican community in which malnutrition was endemic [4]. The work of Zeitlin et al. under the rubric of "positive deviance" similarly sought to isolate specific behaviors that supported child growth in conditions where poor growth was normative [5–7]. Engle et al. reported on "caretaker competence" [8], and Pelto et al. suggested that the significant associations between indicators of "maternal management" and growth, which they found in their work in central Mexico, reflected the operation of differential caring [9]. A study in southern Brazil demonstrated that unobtrusive indicators of maternal behavior, which reflect caring, were risk factors for persistent infant diarrhea and malnutrition [10]. Such was the expanding level of interest that, by the late 1980s, Pelto claimed that "the concept of 'maternal care-giving' has received increasing attention…as a primary intervening or proximal factor in nutrition" [9, p. 729]. She went on to suggest that "among the components of care-giving for which direct links to nutrition can be traced are food selection and preparation practices, which affect food safety and nutrient density, feeding practices, management of illness, and an array of psychosocial actions that influence endocrine responses and other physiological functions in the child" [9, p. 729].

In 1990, UNICEF published a document, *Strategy for improved nutrition of children and women in developing countries*, in which they introduced the "UNICEF conceptual framework for determinants of nutritional status" [11]. This framework has had a major impact on current thinking about childhood malnutrition. As Pelletier recently noted, "This framework has become one of the most familiar images within the international nutrition community and has helped foster improved understanding and dialogue about the nature and causes of malnutrition" [12, p. 1]. In the original model, which has since been modified and elaborated, inadequate dietary intake and disease are the most *proximate* (immediate) causes of malnutrition. The *underlying* causes, which give rise to the immediate causes, are grouped into three main categories: insufficient household food security, inadequate maternal and child care, and insufficient health services and unhealthy environments. These, in turn, are the product of the *basic* causes that rest in economic structures and political and ideological superstructures, which affect resources and controls. In the model, education is placed in a mediating position between the basic and the underlying causes.

The framework has helped to clarify thinking about the relationships of macrolevel to microlevel factors in affecting nutritional status. By laying out the levels of determinants from basic, through underlying, to immediate causes, the model helps both investigators and program personnel to situate their particular activities within the larger framework of causation.

The focus on "care" as it relates to childhood malnutrition, and the intellectual development of this concept can be traced through a series of papers and meetings. At the International Conference of Nutrition in 1992 the first steps toward defining care were made [13, 14]. This was followed, in 1995, by a conference held at Cornell University for the purpose of reviewing available knowledge related to child care, growth, and development [15].

Among the most notable efforts to advance the concept of care in nutrition are the activities undertaken by the International Food Policy Research Institute (IFPRI). They sponsored a major effort to describe the concept of care and strategies for measuring it [16]. A recent IFPRI Discussion Paper [17] takes these ideas further in an analysis entitled *Assessing care: progress towards the measurement of selected childcare and feeding practices, and implications for programs*. The authors conclude that "a variety of useful indicators and approaches exist for the assessment of hygiene, child feeding and caregiver-child interaction behaviors" [17, p. 80]. They go on to make some recommendations on how to use these in programmatically directed research.

Other strands of research have made important contributions to the emerging emphasis on the behavioral components of infant feeding. Beginning with her research in India on household responses to diarrhea, Bentley initiated a series of investigations on the relationships of complementary feeding behaviors to cultural beliefs and household conditions. She showed that decisions about what and how to feed were the result of complex interactions between beliefs, economic resources, and child anorexia, and that in feeding their children caregivers made behavioral adjustments in their attempts to reconcile these competing factors. The Dietary Management of Diarrhea project [18–20] presented the opportunity to compare the "forced-feeding" behaviors of some Nigerian mothers with the "passive-feeding" mode of many mothers in the Peruvian highlands. This led to further exploration of the concept of "feeding style" and its significance for nutrition [21, 22].

In their studies of American mothers, Birch and Fischer [23] distinguished three feeding styles, to which they gave the labels "controlling," "laissez-faire," and "responsive." A controlling feeding style is characterized by behaviors that are intended to control when and how much the child eats. Birch and Fisher found that some children who experience this style of feeding are unable to self-regulate their energy intake.

They suggested that the intermediate position between highly controlling and noninteractive is appropriately characterized as responsive. A laissez-faire feeding style refers to the type of noninteractive caring behavior that has been described for a number of cultural settings [24, 25]. The relationship of feeding styles to larger cultural conditions, particularly parental beliefs or "ethnotheories," has also been examined [26, 27].

Another strand of research that directs attention to the significance of complementary feeding behaviors consists of investigations of the relationships of maternal education, socioeconomic status, and nutrition of young children in developing countries. The relationships of maternal education to child health and nutrition outcomes have been extensively documented over a considerable period of time [28]. However, survey data analyses generally have not provided a means of understanding the underlying dynamics of these associations. In the last decade, a series of epidemiological and observational studies aimed at identifying the mechanisms by which the caregiver's education is translated into better growth and health outcomes points to the fundamental role played by maternal caring behaviors, particularly in connection with complementary feeding [29]. The interpretation of the epidemiological analyses, augmented by the observational studies, suggests that exposure to schooling produces generalized changes in the perceptions and attitudes of young women, which result in a greater awareness of children's needs, and this, in turn, leads to changes in care-related behaviors. Epidemiological studies in Benin and Bangladesh have found that the capacity to act on these perceptions depends on having a basic, minimal level of economic resources. For mothers who struggle to cope in the poorest economic conditions, education does not relate to child growth, nor does it predict growth in the most well-off strata [30, 31].

Although not explicitly behavioral in orientation, there are also other bodies of research that point to the role of the caregiver's feeding behavior with respect to the adequacy of complementary feeding. For example, Brown et al. conducted a series of clinical studies on the effects of different frequencies of feeding and meal composition on energy intake, and these results, as well as a body of data from observational studies, provide compelling evidence about the importance of feeding frequency for child growth [1]. The scheduling of feeding is but one aspect of a large set of behaviors that determine the content, quality, and safety of the complementary diet.

The expanding dimensions of complementary feeding

The introduction of "care" (or caregiving) into our understanding of complementary feeding requires a broadening of activities in research and programmatic action. Several additional dimensions need to be added to augment the focus on *what is fed*. These

additional dimensions can be described as *how* food is fed, *when* food is fed, *where* food is fed, and *who* is giving the food.

The dimension labeled *how* involves several aspects, including feeding style, the utensils that are used to offer the food, and food preparation and preservation activities. *When* refers primarily to the scheduling of feeding and requires attention to frequency and degree of flexibility. *Where* is concerned with the feeding environment and includes issues of distraction, safety, comfort, and potential for interaction. *Who* directs attention to the relationship of the child with the individual who is feeding him or her, whether it is the mother or an adult to whom the infant has a primary attachment, or another familiar adult, an older child, a day-care worker, or a hired caregiver.

For heuristic purposes, "complementary feeding practices" can be defined as consisting of two main components: the biological component, which is concerned with what is being fed, and the behavioral component, which is concerned with issues of how, who, when, and where.

Feeding behaviors that reflect principles of care

The original UNICEF conceptual model defined care as "the provision in the household and the community of time, attention, and support to meet the physical, mental, and social needs of the growing child and other household members" [11]. In a theme paper prepared for the International Conference on Nutrition (ICN), Engle [14] amplified the basic definition with a categorization of types of care behaviors. She identified six categories of care: care for pregnant and lactating women, breastfeeding and the feeding of very young children, psychosocial stimulation of children and support for their development, food-preparation and food-storage behavior, hygiene behavior, and care for children during illness, including care-seeking behavior.

Moving from this set of categories toward programmatic action, a logical next step for complementary feeding would be to identify some specific behaviors for breastfeeding and the feeding of very young children, and food-preparation and food-storage behavior, since these are the areas that apply directly to complementary feeding. The following are examples of the kinds of recommendations that might be derived if one takes a narrow behavioral focus:

» With respect to *how to feed*: ensure that feeding utensils are available and clean; ensure that sanitary conditions are maintained in the preparation and storage of food; pay attention to how much the child is eating and ensure that the intake is adequate.
» With respect to *when to feed*: ensure that food is fed frequently enough during the course of the day to meet the young child's nutritional needs, given his/

her limited gastric capacity and the nutrient density of the complementary foods.

» With respect to *where to feed*: ensure that the eating environment is clean.

» With respect to *who does the feeding*: ensure that the caregiver is knowledgable and experienced.

Although these recommendations technically represent caring behaviors, they are so narrowly focused that they fail to consider the larger conception of "care" that is intended by the UNICEF framework. At the heart of this conception is the idea of "psychosocial care." In their 1996 paper on "Care and nutrition: concepts and measurement" [16], Engle et al. provide a definition of psychosocial care as "the provision of affection and warmth, responsiveness to the child, and the encouragement of autonomy and exploration" (p. 34). A primary feature of this definition is that it calls attention to the fact that there are two parties involved in psychosocial care—the adult caregiver and the young child. The actions are not one-way arrows from the adult to the child, but, to the contrary, the child's needs for autonomy and freedom to explore are also highlighted. It is in the *interaction* in the adult–child dyad that psychosocial care is grounded.

The fundamental principles of psychosocial care include accurately perceiving and interpreting the child's signals, responding adequately and promptly, and using "scaffolding" in interactions. Scaffolding here refers to a mode of interaction in which the adult's behavior is adjusted over time to the emerging skills of the young so that the child is adequately challenged but not overwhelmed and is able to use his or her behavioral and expressive skills.

When principles of psychosocial care are integrated with other aspects of caregiving, a different paradigm begins to emerge. We have proposed the concept of "responsive parenting" as a way of capturing or expressing the dyadic nature of effective caregiving [32]. This phrase is intended to call attention to the interactive nature of caring for infants and young children, in which the caregiver and the child are engaged in mutually reinforcing positive (and occasionally negative) actions.

If the foregoing principles are then applied to the domain of complementary feeding and integrated with emerging knowledge about the conditions that promote adequate intake of complementary foods, we can begin to construct a set of "best-practice feeding behaviors." These behaviors should be based on the hallmark principles of attending to and responding to the child's signals. They can also take advantage of the essential and repeated act of feeding to promote the evolution of the child's development through scaffolded interactions. These behaviors sustain and reinforce the strong affective ties that develop between mother and infant during breastfeeding and provide a means for extending these ties to other primary adults in the infant's world. The set below is offered as a first approximation. It is intended as a catalyst for a more systematic effort that would include empirical testing, as well as a review from multiple perspectives of theory and practice.

Some best-practice feeding behaviors

» Feeding with a balance between giving assistance and encouraging self-feeding, as appropriate to the child's level of development.

» Feeding with positive verbal encouragement, without verbal or physical coercion.

» Feeding with age-appropriate as well as culturally appropriate eating utensils.

» Feeding in response to early hunger cues.

» Feeding in a protected and comfortable environment.

» Feeding by an individual with whom the child has a positive emotional relationship and who is aware of and sensitive to the child's individual characteristics, including his or her changing physical and emotional states.

This set of best-practice behaviors needs to be joined with another set of behaviors that specify best-practice guidelines from the perspective of food safety and hygiene. The augmented behavioral guidelines can then be melded with recommendations on what to feed (designated from a biological perspective) to create a set of *generic* guidelines for complementary feeding practices to promote child growth and well-being. We emphasize that global guidelines are, by definition, generic. To be useful for programmatic action or for research, they must always be translated to a specific context.

Part 2. Cross-cultural patterns in feeding and young child feeding practices

Case studies of complementary feeding

Methods

To obtain an illustrative group of case studies, we began by screening the Human Nutrition database for records published within the last 20 years that contained information on "weaning" and "culture." The following search terms were used: weaning, weaning foods, community, cultural practice, culturally appropriate, culturally sensitive, wean, food, complementary foods, complementary feeding, infant diet. These results were augmented by a search in the BIOSIS Previews database using the following search terms: medical anthropology, infant feeding, infant diet, behavior. The anthropological literature was explored using the Eureka database of the Tozzer Library of Harvard University. In addition we reviewed medical anthropology journals (e.g., *Medical Anthropology* and *Medical Anthropology Quarterly*) for articles related to child nutrition. Finally, other

studies were located in bibliographies of articles and monographs identified with the previous methods.

Our first criterion for selection of cases was the availability of at least some data on nutrition-related care practices. That is, we examined the studies for evidence of information on the caregiver (*who*), the feeding style (*how*), the feeding environment (*where*), and the frequency and scheduling of feeding (*when*). Since it is not our intention in this paper to review the biological aspects of food practices, the inclusion of detailed data on what is being fed and the schedule of introduction of complementary foods was not a criterion for case selection. However, in the ethnographic sketches in the Appendix we include some notes on *what* in order to provide sufficient nutritional context to interpret the behavioral information.

With respect to *why* (the determinants of feeding practices), we examined studies for information on the following, potentially modifiable, determinants of care practices: maternal time allocation and competing demands on women's time; beliefs, knowledge, and perceptions; the health of the caregiver and other family members; and social pressures, social support, and normative expectations. (The rationale for this selection of determinants is provided below.)

In addition to the adequacy or richness of information, our final selection of cases was based on geographic distribution. The 18 ethnographic studies are distributed by region as follows:

» Africa: Kwara State, Nigeria; central Tanzania; Bamako, Mali; and Chivi District, Zimbabwe
» Latin America: Brasilia, Brazil; eastern Guatemala; highland Peru; and Santo Domingo, Dominican Republic
» Asia: Wamrong Subdistrict, Bhutan; rural villages, central Bangladesh; northwestern Nepal; and peri-urban Manila, Philippines
» Oceania: Usino, Papua New Guinea; Malaita, Solomon Islands; and rural Trobriand Islands
» North America: United States (urban Maryland, urban Kentucky, and urban Pennsylvania)

The sample of 18 case studies is not a representative sample in the technical sense, as they were not randomly selected from the larger database of ethnographic studies. Rather, they are random in the colloquial sense of common English usage, reflecting the coincidence of where investigators with an interest in complementary feeding behaviors happened to conduct their research. We relied almost entirely on articles from peer-reviewed journals, which reflect another selection process, including the motivation of the investigators to publish their observations in a readily accessible source. No doubt there is a considerable body of useful data on the behavioral aspects of complementary feeding in postgraduate degree theses and in unpublished reports.

To assist in the construction of the case study

sketches, the information in the articles was transferred to a matrix that provided a common framework from which to write the sketches. In some cases we used several articles to compile the information, and for others only a single source with relevant data was available.

Results related to behavioral components of complementary feeding practices

As will be immediately apparent in reading the sketches, virtually all of the reports have significant information gaps in relation to the framework. Nonetheless they are informative about current practices and permit some examination of commonalities and divergencies in complementary feeding behaviors. Tables 1, 2, and 3 provide summaries of the key parameters across the 18 studies, but we urge the reader to examine them in the more amplified version in the sketches.

Modifiable determinants of complementary feeding practices

In addition to describing behaviors, we reviewed descriptive information in the case studies on potentially modifiable, proximal determinants. We examined these determinants within the context of caregiving behaviors. In his opening discussion on the contributions of the UNICEF Framework to current understanding of malnutrition, Pelletier suggested that, despite its widespread referencing, the nuances implied in the framework have not been uniformly appreciated. Among the more significant and subtle nuances, he notes, is that the "effects of food and health are *contingent on care*" [12, p. 2, emphasis added]. Thus, in the design and development of interventions to improve feeding practices, it is important to identify those determinants of care behaviors that are potentially modifiable.

It is very difficult to obtain a systematic picture of the links between specific sociocultural factors and feeding practices on the basis of currently available data. Consider, for example, the problems that Leslie encountered in her attempt to examine the relationship of maternal employment to the age of introduction of complementary foods [33]. She found that methodological problems in the existing descriptive information and the absence of quantitative data on critical variables precluded the type of analysis that is required to arrive at systematic generalizations. Ten years later, Brown et al. [1] revisited this issue. Based on a second review by Van Esterik [34], they suggest that "A review of more recent studies offers little reason to modify these [Leslie's] judgments" (p. 113).

For the case study sketches, we selected four categories of determinants: maternal time allocation and competing demands on women's time; beliefs, knowledge, and perceptions; health of the caregiver and other family members; and social pressures and social support, particularly in the caregiver's immediate social network.

TABLE 1. How complementary food is fed[a]

Manner of feeding	Case study[b]																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Vehicle																		
Caregiver's hand	x				x				x	x	x							
Caregiver's mouth														x				
Bottle						x		x		x		x		x		x	x	
Cup, bowl, or spoon		x	x	x		x	x			x		x	x			x		x
Child's hand										x								
No information															x			
Method																		
Spoon held by caregiver				x								x				x		
Food placed in child's hand						x								x				
Caregiver premasticates												x		x	x	x		
Caregiver force-feeds if child is resistant	x																	
Child expected to self-feed			x				x										x	
No information		x				x		x	x				x					x
Feeding style																		
Inadequate information to specify		x		x		x		x	x			x	x					x
Possibly interactive, but cannot judge whether the caregiver is responsive				x						x	x			x	x	x		
Controlling	x																	
Laissez-faire			x				x											

a. Except for the rows with no information, x indicates that the practice was explicitly reported by the investigator.
b. 1 Nigeria, 2 Tanzania, 3 Mali, 4 Zimbabwe, 5 Brazil, 6 Guatemala, 7 Peru, 8 Dominican Republic, 9 Bhutan, 10 Bangladesh, 11 Nepal, 12 Philippines, Papua New Guinea, 14 Solomon Islands, 15 Trobriand Islands, 16 Maryland (USA), 17 Kentucky (USA), 18 Pennsylvania (USA).

TABLE 2. Who feeds complementary foods

Caregiver	Case study[a]																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mother is with the child during the day																		
Mother	x			x	x	x		x	x				x					x
Mother + grandmother														x			x	
Mother + adult female relative										x				x	x		x	
Mother + older sibling							x			x				x			x	
Mother + father														x	x	x		
Child feeds self			x															
Mother is away during the day; child has another caregiver																		
Grandmother	x	x														x		
Other adult female relative											x	x			x			
Sibling	x	x								x								
Unrelated caregiver		x																x

a. 1 Nigeria, 2 Tanzania, 3 Mali, 4 Zimbabwe, 5 Brazil, 6 Guatemala, 7 Peru, 8 Dominican Republic, 9 Bhutan, 10 Bangladesh, 11 Nepal, 12 Philippines, Papua New Guinea, 14 Solomon Islands, 15 Trobriand Islands, 16 Maryland (USA), 17 Kentucky (USA), 18 Pennsylvania (USA).

TABLE 3. Frequency of feeding complementary food[a]

Frequency	Case study[b]																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1/day									x									
2/day		x				x	x											
3/day											x	x			x			
≥4/day			x		x	x				x						x		
Explicit mention of snacks								x							x	x		
No information, or difficult to determine from the report	x			x				x					x	x			x	x

a. There was not enough information on scheduling of feeding to permit tabulation from the case studies.
b. 1 Nigeria, 2 Tanzania, 3 Mali, 4 Zimbabwe, 5 Brazil, 6 Guatemala, 7 Peru, 8 Dominican Republic, 9 Bhutan, 10 Bangladesh, 11 Nepal, 12 Philippines, Papua New Guinea, 14 Solomon Islands, 15 Trobriand Islands, 16 Maryland (USA), 17 Kentucky (USA), 18 Pennsylvania (USA).

The selection of these categories was based on a thematic analysis of the descriptive ethnographic reports themselves, a broad, if diffuse, body of social science theory, and, most importantly, the fact that these determinants are potentially amenable to change through various types of intervention activities. Thus, they provide an important link between the insights that can be gained from ethnographic description and the development of programs. However, in focusing on these categories it is not our intention to suggest that they constitute the definitive set of proximal, modifiable determinants. We believe that they are likely to be important, to varying degrees, in many different cultural settings. Other determinants may also be significant, and the identification of specific constraints must be sought in each local context. Moreover, the focus on these specific areas of caregiver and household-level factors does not imply that interventions should be directed solely to caregivers and households. To the contrary, both the design and implementation of interventions demand attention to the social context, particularly the community context, where both the resources and constraints to behavior change are likely to be found.

Maternal time allocation and competing demands on women's time

To understand a mother's ability to satisfy the needs of her child, one must know about the range of her competing responsibilities and their compatibility with child-care practices. Although women's activities vary greatly across geographic and cultural regions, and in relation to economic conditions, the model of the mother-as-domestic-homemaker is becoming increasingly rare, even in societies where this was formerly a common situation. In most societies today, a significant proportion of women with small children must engage in some form of income-producing activities, which are typically structured in a manner that creates powerful constraints on caring. Even in more traditional, subsistence-oriented communities, food-production responsibilities and other domestic, non-child-care activities place heavy time-allocation demands on women. The case study materials described in the ethnographic sketches illustrate the nature of these multiple demands and women's perceptions about the relationship of these demands to complementary feeding behaviors.

Beliefs, knowledge, and perceptions

When public health and nutrition professionals from Euro-American societies and cultures first encountered the diversity of cultural beliefs and perceptions about food, health, and well-being, there was a tendency to invest them with strong deterministic power in the explanation of why people ate as they did. The concept that "ignorance" or bizarre cultural beliefs explained why people in other societies "ate poorly" or had "bad dietary habits" was an explanation that permitted Euro-Americans to ignore the role of poverty and resource constraints as causes of malnutrition. It put a premium on inventions designed to teach people better nutritional habits.

On the other hand, clinical and research professionals with greater sensitivity to the conditions of daily life in poor communities countered with economic, materialist explanations, and questioned whether beliefs had any causal role, at least in undernutrition. To the extent that the materialist position entertained any acknowledgment of cultural factors, there was a tendency to stress the wisdom of traditional cultural knowledge, with little room for any role for educational interventions.

A more balanced view, which we subscribe to here, is that cultural beliefs, knowledge, and perceptions influence food behaviors to varying degrees, except under the most severely constrained economic conditions [30]. Many aspects of culturally shared understandings and interpretations are positive with respect to current scientific knowledge, some aspects are best regarded as neutral, and some are counterproductive from the perspective of contemporary biomedical theory. The complex nature of beliefs in relation to infant and

young child feeding behaviors is clearly apparent in the case studies.

Health of the caregiver and other family members

The ethnographic literature contains many reports concerning cultural perceptions about the effects of the mother's state, including maternal illness, on the quality of breastmilk. If a mother is angry, tired, or ill, her milk can become spoiled or tainted, and illness in the breastfeeding infant is often attributed to such conditions in the mother. Much less is known about how the mother's health is perceived to affect complementary feeding. Is it that investigators have failed to ask, or are such ideas absent in most cultural systems? From observational and epidemiological data there is evidence that the caregiver's health (physical and mental) has important effects on the outcome for the child. Currently, there is much concern about this determinant with respect to HIV/AIDS. A few of the case studies contain relevant material on the influences of the caregiver's health and the health of other family members on behaviors related to complementary feeding.

Social networks, social pressure, and normative expectations

The importance of social support and social expectations for infant feeding decisions and behaviors became very clear with the advent of systematic research on breastfeeding versus bottle-feeding [35–37]. As is apparent from the case studies, examination of the effects of the immediate social group on complementary feeding behavior is less fully reported and less well understood. As with breastfeeding, it is likely that the social group surrounding the caregiver–child dyad can exert both positive and negative pressures on complementary feeding behaviors. These, in turn, reflect more widely shared, normative expectations. On the other hand, the significance of medical and health personnel in influencing caregivers' practices represents the introduction of new ideas and new sources of social pressure.

Generalizations concerning the case studies

The ethnographies contain few, if any, surprises, but they illustrate and reinforce a number of issues that have previously been identified. They are particularly useful because of the nature of the research process that underlies many of the studies—namely, the use of in-depth interviews rather than preset questions. In some cases the investigator used directed questions, such as "Is there anyone you consulted concerning advice on how to feed your child?" Such open-ended questions are clearly valuable, and they are essential for deriving quantitative estimates of beliefs, attitudes, and behaviors. But there is also a role for less directed methods. Many of the data reported in these papers were obtained through thematic analysis of field notes from interviews and observations. Thus they present more "emic" views (the perspective of individuals who are "insiders" to their culture) than is typical of most of the data in epidemiologically oriented nutrition research. That is, they reflect the beliefs, values, and experiences of the local community and the people who are being interviewed to a greater degree than is usual in the case of preformed questionnaires, even when the latter are open-ended. Among the themes and generalizations that can be derived from the case studies, we would like to draw attention to the following.

Feeding infants is a family affair. The significance of the effects of male partners, friends, and women of older generations on breastfeeding has been well documented in research in the last two or three decades. To date, the importance of the family in complementary feeding has been less clearly revealed. However, in almost all of the case studies, we see that complementary feeding of the infant or young child is very much a family affair. As can be seen in table 2, mothers generally have the primary responsibility for preparing and feeding complementary foods, but other people are also involved, and often (although not always) these other people are family members. Not shown in the table, but apparent in the sketches, are the different types of involvement that can be identified. Some family member involvement is in the form of affecting what the mother does and can do, including constraints on her decisions as well as her behaviors. One could label this as "advice with a bite," because it reveals the authority of other family members to determine the feeding practices in which mothers are engaged.

Another form of family involvement is in the preparation of complementary foods. Perhaps the most common form of family participation in complementary feeding is the family's role in the actual feeding of infants and young children. We have no quantitative data across the globe on what proportion of infants receive what proportion of their complementary food from someone who is not their mother, but it is probably safe to say that it is not negligible. The significance of these alternative caregivers for child growth outcomes is unknown, and it is unlikely that it can be derived from existing sources of data. The ethnographic reports suggest that there are potentials for both positive and negative consequences. For example, emotionally engaged grandmothers in families where mothers are experiencing situations and pressures that affect their ability to carry out effective complementary feeding may provide the type of care that the young child needs. On the other hand, there may also be negative consequences. For example, the public health community has voiced concern that artificial nipples on feeding bottles interfere with breastfeeding by affecting the babies' preferences. What are the effects of unpleasant, controlling, or nonresponsive feeding of complementary food by alternative caregivers with

more attenuated relationships to the child than that of the mother? In theory, these experiences may be very disruptive of the development of good feeding behaviors on the part of the child.

Balancing the demands engendered by complementary feeding against all the other demands and needs of an adult woman's life is a fundamental issue for mothers. One of the most consistent themes in the case studies was the problem of time and the relationship of complementary feeding activities to other, competing demands. The problem of not having enough time for all of the work and other activities in which people engage is a litany of professional life in industrialized countries. But it is equally salient for mothers in situations as diverse as the Nepalese highlands, Bamako, or periurban Manila. Women select complementary foods that can be prepared quickly, not only to save fuel, but also to save time. They change traditional food-preparation techniques in favor of those that are less time-consuming. They feed quickly or noninteractively in order to save time and to use the time taken by the child for eating to accomplish other tasks. They feed less often in order to save time for other tasks. They prepare complementary foods early in the day to avoid disrupting other work by having to prepare complementary foods just before feeding them. The time factor thus affects the selection of foods, their preparation, and feeding style.

The issue is not simply time, but time in relation to other activities, other responsibilities, and other demands. Thus, the themes that emerge are related to larger issues of household economic organization and domestic social management—to tasks, resources, and the expectations of self and others, and the degree of flexibility to make adjustments during the period in which their infants and young children require complementary feeding.

Mothers and other adults have conceptual frameworks in terms of which they make decisions about complementary feeding (what to feed, how to prepare it, and how to feed it). The case studies provide rich descriptive evidence of the "theories-in-use" that guide people's behaviors with respect to what, when, where, and how to feed their children. These can be characterized as "conceptual frameworks" that structure the multiple decisions that people have to make in relation to feeding and caring for their children. Some elements of this framework are directly economic. They concern decisions about how to use household resources and involve giving foods that are affordable, avoiding foods that are regarded as too expensive, and generally structuring the infant's diet in relation to the larger economic issues in the family.

Apart from economic considerations and other issues of time and resource allocation (see above), the conceptual frameworks that are reflected in the data in the case studies involve concerns about what is good for children. The following examples paraphrase some of the ideas that can be found in the ethnographic reports:

» "It is good to give foods that are light foods because heavy foods can make a child sick, irritable, and not active."
» "It is good to give infants bits of adult food so that he or she will learn to like them."
» "It isn't good to give too many different kinds of foods because the child will then expect them later, and as we can't afford them, he or she will be unhappy and difficult."
» "Children need to feed themselves from the very beginning, so they learn to be independent and are able to take care of themselves."
» "The child knows whether he or she is hungry, so it is not good to try and make him or her eat more."

Independently of any assessments one might make about the "correctness" of these views from a biomedical viewpoint, a primary generalization that can be drawn from the case studies is that complementary feeding in all communities is structured by local theories of child well-being and the role of feeding in achieving that.

In most communities, common patterns of complementary feeding behaviors do not conform to best-practice feeding behaviors (as derived from principles of psychosocial care). The data in the case studies are very thin from the perspective of revealing the nature and extent of best-practice feeding behaviors. Consequently, it is difficult to examine these themes in the ethnographic reports. Part of the problem is that ethnographers of feeding practices have had no reason to report on these, because there is no larger theoretical structure in nutrition that would direct their attention to them. A further problem is that the reports tend to focus on common, normative patterns, with much less attention to intracultural or intragroup diversity. Undoubtedly, in every community there are families whose feeding practices reflect principles of psychosocial care, but it appears that, in general, the common practices in many communities are less than optimal.

» *Feeding with a balance between giving assistance and encouraging self-feeding, as appropriate to the child's level of development.* In a few of the case studies, it appears that assistance in feeding is inadequate because caregivers are actively encouraging early independence or assume that the infant can manage without help. This may be the situation with bottle-propping, as well as with a laissez-faire mode of feeding with spoon, bowl, or the child's hand. At the other extreme is the one case of forced feeding, in which there is no assistance but rather insistence. It is difficult to judge the extent to which a balance occurs in other environments.

» *Feeding with positive verbal encouragement, without verbal or physical coercion.* Apart from the potential for physical coercion in the case of hand-feeding in Nigeria, it is very difficult to gauge the extent of encouragement that children are given in the various situations reflected in the case studies. Where parents adhere to the belief that children "know" whether or not they are hungry, it is probable that there is no verbal encouragement to eat. On the other hand, some of the parental concerns and behavioral changes that accompany feeding children who are ill may include greater verbal encouragement.

» *Feeding with age-appropriate as well as culturally appropriate eating utensils.* There is so little information concerning this feature that it is very difficult to assess the frequency of this best-practice behavior.

» *Feeding in response to early hunger cues.* Although many of the studies provided at least passing reference to the number of times per day that children receive food, there is almost no information on how the feeding was scheduled. It appears that in many situations the feeding of complementary food occurs in connection with family meals, which presumably are scheduled not in relation to young children's hunger but to adult work schedules. There are clear exceptions to this, as for example, in the study in Baltimore, where it is likely that, in at least some households, children's hunger cues are the basis for offering foods.

» *Feeding in a protected and comfortable environment.* Protecting infants and young children from environmental hazards emerges clearly as a priority in virtually all of the case studies, and in difficult environments it may actually function to reduce child mobility and opportunities for exploration. However, none of the studies documents a concern for providing a feeding environment that is free of distractions, which may be of significance to intake during the period of complementary feeding. Again, this is an area for which there is so little information that informed generalizations cannot be made.

» *Feeding by an individual with whom the child has a positive emotional relationship and who is aware of and sensitive to the child's individual characteristics, including his or her changing physical and emotional states.* There are virtually no data on this aspect of best-practice behavior in the case study materials. As noted above, the situation of multiple caregivers can be either positive or negative, and the descriptions do not readily permit generalizations about this. However, it seems likely that when young children are left with older sibling caregivers who are themselves still children, sensitivity to the young child's needs and skill in meeting them may not always be present.

Part 3. Implications of the case studies for interventions

Best-practice feeding behaviors in the case studies

Analyses in which the dietary intakes of infants and young children are compared with nutritional recommendations have consistently identified significant problems [1]. The contribution of poor feeding practices to the ubiquitous growth faltering that characterizes most poor populations is generally assumed to be a primary source of the problem. In the language of the framework we proposed earlier, we would say that the problem of inadequate quality and quantity in complementary feeding is fundamentally a problem of "what."

When the focus is mainly (if not exclusively) on "what," planning of interventions is directed to improving access to food and educational activities that emphasize better food selection and preparation. Although we did not undertake a systematic description of the "what" component of feeding practices in the case studies, there is ample evidence to argue for the value of interventions that improve access and increase the families' understanding of children's nutritional needs and how to meet them.

As we suggested above, the arguments for attention to best-practice feeding behaviors should not be viewed as a substitute for "what," but as a call for attention to other factors that can have significant effects on child nutrition, growth, and development. These are *in addition to* the potential benefits of improving food selection and preparation. What is not clear from the present state of scientific knowledge is whether the benefits will be additive or synergistic.

Even in earlier periods when ethnographers adhered to a philosophy of holistic description, investigators were concerned about selection bias and looked to theory for guidance on what to record in their field notes and report in their monographs. As nutrition theory emphasizes dietary intake, one would expect to find more details about foods in nutritionally oriented ethnographic studies. With respect to infant and young child feeding, one would therefore expect to see more descriptions of what is fed than other aspects of feeding-related behaviors. This expectation is fulfilled in the case studies, although the level of quantification is usually frustratingly low. On the other hand, some components of complementary feeding, particularly the feeding environment and the feeding schedule, have only recently been recognized as important, so one would not expect to find rich detail in descriptive studies. Thus, our capacity to evaluate these features in the case studies is seriously constrained by lack of data.

To the extent that global judgments can be made for

the case materials reviewed above, there is evidence that care-related practices need to be improved in many cultural settings. The descriptions of common and normative behaviors with respect to care-related components are often suboptimal when viewed through the lens of current theory.

In general feeding, the "how" aspects of feeding styles tend toward the laissez-faire end of the spectrum, whereas the more dramatic opposite pole (controlled feeding or forced feeding) is rare. Both ends of the continuum—laissez-faire and controlled feeding—reflect a theme that is common throughout the case studies: the view that feeding children during the period from 6 to 24 months is time-consuming and interferes with what are implicitly viewed as more pressing and more important demands. Patient, engaged interactive feeding is not culturally normative in most places.

Scheduling of breastfeeding during infancy is often described in ethnographic reports and is usually reported as frequent and on-demand. When solid foods are added, the continuation of on-demand breastfeeding appears to be typical in situations where the mother and child remain together during the day. At the same time, the common situation with respect to scheduling is to feed solids two or three times a day. However, the relationship of breastfeeding (or feeding of breastmilk substitutes by bottle) to feeding of solids is generally not well reported, particularly in situations in which the child is not with his or her mother for long periods during the day [38]. Although the evidence is not as clear as one would wish, it is probably the case that in most settings the "when" of complementary feeding does not meet the recommendations promoted through the Integrated Management of Childhood Illness [39]: at 6 to 12 months, three times a day for breastfed children and five times a day for children who are not breastfed; at 12 to 24 months, five times a day.

Detailed information on the feeding environment (i.e., where complementary foods are given) is almost nonexistent in the case reports. As noted above, this omission is to be expected, since there has been very little systematic investigation of the effects of the feeding environment on the child's consumption. On the other hand, investigators generally tend to report the practice of leaving children routinely at home while the mother goes out to attend to other activities. This information is usually provided in the context of descriptions of who is taking care of the child. Two types of arrangements are common when the mother is not the sole caregiver: care is provided by adult women relatives (grandmothers, sisters, or sisters-in-law) or by older siblings (sometimes by another child who may be only a few years older). It is less common to find that fathers or unrelated adults are caring for young children, either in the child's home or in a day-care home or day-care center. However, the importance of day care as the place where children are fed and otherwise cared

for is expanding throughout the world, particularly in urban areas. The quality of feeding care behaviors by alternative caregivers is very difficult to assess in case studies, but it is probably safe to conclude that these vary across a spectrum from excellent to very poor, and in many situations it is likely that this compromises dietary intake in early childhood.

Some of the reports about the "where" and "who" of young child care also document the ambivalence with which women leave the care (including nutritional care) of their young children to others. In every society, families worry about the safety, health, and well-being of their young children. For a preverbal infant, families are usually quick to respond to crying and often interpret it as a sign of hunger, unless there are clear signs that point to another source of distress. On the other hand, competing demands on an adult's time, particularly mothers, requires compromises. These compromises are reflected in statements of ambivalence and concern, some of which are evident in the case studies we reviewed.

Implications of the findings for interventions

In the preceding paragraphs we suggested that, in many settings, there are features of common caregiving practices that do not support the optimal growth and development of children. The implications of this analysis are the following:

» There is a need for interventions to improve nutrition-related caregiving practices during the period of complementary feeding.
» Nutrition-related caregiving behaviors are always embedded in a much larger complex of family and caregiver activities and a broad sociocultural context.
» Therefore, interventions undertaken for the purpose of changing specific behaviors must be designed in relation to their sociocultural context and in relation to situation-specific determinants.

Many years ago, Gordon et al. called attention to the problem of "weanling diarrhea" [40], thereby setting off a series of investigations and discussions concerning the tradeoff between the consumption of complementary foods and the increased risk of diarrhea, which is often referred to as "the weanling dilemma" [41–43]. When we examine this critical period in the child's life from the perspective of feeding-related behaviors, we see that the weanling dilemma extends beyond the arena of nutrients and disease—it includes a series of dilemmas for caregivers as well as babies. One of the most difficult is balancing the demands on mothers to feed effectively in relation to other demands, particularly time demands. These time and resource dilemmas have been present in every social system, but they are exacerbated in contemporary societies, whether because of wage-labor and other income-earning conflicts or because of conflicts in food-production

activities. Feeding styles have evolved that stress speed over psychosocial interaction.

Another recent factor that may have influenced the development of noninteractive feeding styles is the loss of premastication as a primary technique for transforming adult foods into a form that can be consumed by the young child. Although older ethnographies are not as detailed as one would wish, it appears that premastication occurs as a bite-by-bite technique, which requires the caregiver to follow the child's pace.

Regardless of the initial determinants, the effect of changing norms of and expectations about feeding style is that even in household situations where the tradeoffs are less clear, there may be tendencies to adopt styles that are suboptimal. One of the major challenges for the development of locally appropriate intervention will be to find ways to balance demands on the caregiver's time with the promotion of a responsive feeding style.

Another major challenge that will need to be addressed in the development of interventions is what methods to use to promote the learning of new food-related child-care behaviors. According to Raphael, Margaret Mead and colleagues were among the first to point out that breastfeeding is not a natural behavior that women automatically know how to do well [44]. They pointed out that it is a complex behavior that requires learning and modeling. They identified the significance of the role of the *doula* (the traditional breastfeeding counselor) and pointed out that in many communities this vital role had disappeared. Thus, they attributed some of the decline in breastfeeding to the loss of the *doula* and advocated social interventions to replace this role. In the past two to three decades, the promotion of breastfeeding has focused heavily on teaching, modeling, and the provision of supportive structures. The success of this strategy is becoming widely understood.

The feeding of complementary foods is also a complex behavior, even more complex than breastfeeding—not least because it also depends on the availability of food. ("Availability" is used here in multiple senses, including the knowledge and skills to prepare and feed foods so that they are truly available to the young child, and availability in the larger sense of having resources to access them.) Like breastfeeding, complementary feeding needs to be learned through behavioral modeling, as well as through the acquisition of knowledge. Like breastfeeding, it also requires social support. In short, we need *doulas* for complementary feeding. Developing systems to provide them will be one of the significant challenges for complementary feeding interventions.

Adequate complementary feeding is obviously contingent on the availability of appropriate foods. An essential component of any intervention program is to ensure that behavioral-change interventions are undertaken in a context in which access to appropriate foods is assured.

As with all activities that are undertaken with the goal of improving well-being, the planning of interventions to improve feeding practices needs to follow basic principles of community action. These principles include:
» Obtaining knowledge about current behaviors.
» Obtaining an understanding about the key context conditions and determinants of current behaviors.
» Working with communities to design interventions that are responsive to the context and to local values.
» Building on principles and strategies of individual, familial, and community behavior change.

Finally, we need to remember that feeding infants and young children is a complex challenge for all species, including our own, and now, when rapid social and cultural change has become the human condition, we no longer have the advantage of long-term cultural evolution to guide our management of the process. In the past few decades we have developed a number of strategies to support the first part of the process—breastfeeding—although there are still many challenges, particularly in relation to exclusive breastfeeding. While continuing to work on these, it is essential to develop more creative and effective support for the continuation of the process so that the young child is protected through the entire journey from the cutting of the umbilical cord to the point at which he or she can be adequately nourished from the family pot.

Appendix: Case studies

Geographic area: Africa

Case study 1. Nigeria (Kwara State) [19, 45]

Background

This research was carried out in the seven Yoruba-speaking local government areas of Kwara State in Nigeria. In the first stage of the research, a series of ethnographic, epidemiological, dietary, and clinical research methods was used to describe infant feeding practices as well as the frequency and the determinants of hand-feeding, a traditional practice for feeding young children among the Yoruba of Nigeria. In the second phase, a culturally acceptable intervention to improve weaning practices and infant nutrition was developed.

A cluster sampling technique, in which the probability of selecting an individual community was proportional to the population size, was used to choose the seven communities. Within each community, mothers or other caregivers of infants under three years of age were eligible to participate in the study. Overall, 2,655 mothers were interviewed from 18 rural and 12 urban communities. The authors argued that an interdisciplinary approach and community participation are required to develop new weaning recipes that are culturally appropriate, acceptable, and sustainable.

Food type and age of introduction (what)

Almost all (96%) of the children 6 to 11 months of age were supplemented with a liquid pap (*eko*) prepared from fermented sorghum or maize paste (*ogi*). Other foods fed to children in this age group included sugar (45%), beans (53%), yam (30%), solid pap (17%), condensed milk (23%), infant formula (15%), ground nut (12%), and soybeans (5%).

Food preparation and feeding style (how)

The most commonly practiced mode of feeding *eko* to infants was to hand-feed the liquid pap. The authors described this as follows:

"During hand-feeding the child is usually held either supine across the mother's lap or with the head suspended from the mother's leg while she is seated. The mother then places her cupped hand over the child's mouth to serve as a funnel for a liquid or semiliquid food. When the child is unwilling to eat, the mother can force liquids into the child's mouth by simultaneously occluding the nose with her cupped hand. The child is then unable to breathe until after swallowing all of the food."

Mothers also reported that they force-fed more when their children resisted hand-feeding. According to the authors, nearly 80% of both urban and rural mothers reported this practice.

Caregivers (who)

About 80% of the women interviewed reported that their children accompanied them during their market work, while 11% left the children with their grandparents. The remainder had their children cared for by older female siblings, other relatives, or a neighbor.

Feeding frequency and schedules (when)

No information is given on daily routines. Pap (*eko*) was the most commonly consumed food among both rural and urban infants. It was consumed at least once a week by nearly all the infants by the time they were one year of age.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

The mothers said they favored hand-feeding because it saved time. Using observational data on hand-feeding, force-feeding, and spoon-feeding, the authors demonstrated that mothers completed a feeding episode in less than three minutes if they hand-fed or force-fed, whereas the feeding time more than doubled when the child was spoon-fed. On the basis of this observation, they suggested that the amount of time it takes to feed a child may be an important constraint in motivating mothers to change infant feeding patterns.

Mothers in rural areas felt that infants should receive only breastmilk and pap until they were close to one year of age (although the survey data revealed that about half of the children received some amount of other foods between 6 and 12 months). The foods that were offered to this age group were those that mothers considered to be "light." According to the authors, the traditional *eko* was considered an ideal infant food, one that protects children from illness and from problems that are associated with the introduction of other foods. Mothers were concerned that an earlier introduction of solid foods, particularly "heavy" solids such as pounded yam, could result in the child becoming "heavy" (*wiwo*), which is considered an unhealthy state. A heavy child is "heavy to pick up," "sick," "irritable," and "not active." Some mothers described the classic symptoms of kwashiorkor as a variation of *wiwo*. A healthy child was one who was considered "light"

(*fuye*), defined as "active, not sick, and light to pick up." In addition to these folk classifications of child health, many mothers felt that if foods of a solid or semisolid consistency were introduced too early, the child simply could not swallow them. Some mothers reported that a child who received "adult" foods, such as pounded yam and cassava, "too early" would not be able to develop or walk correctly, and that this could result in the onset of illness, including diarrhea.

The role of social expectations is illustrated by the common statement about force-feeding to the effect that "[we] have always fed this way." Interviews with grandmothers confirmed that this was indeed a traditional feeding pattern, one that has been passed down for generations. Because there were no apparent differences among urban and rural mothers in the prevalence and hand- or force-feeding, and also because socioeconomic, demographic, and religious factors did not explain prevalence, it appears that despite a large degree of acculturation and modernization in Nigeria, this mode of infant feeding is a traditional and widely practiced behavior that is supported by social expectations about what constitutes good parenting.

Case study 2. Tanzania (semipastoral) [46, 47]

Background

This research was conducted among the Wagogo, a semipastoral people who live in Chigongwe, central Tanzania. Data were collected from June 1989 to July 1991 and from March 1992 to August 1992. The goal of the study was to bring out the importance of attitudes and practices connected with breastfeeding and the introduction of semisolid food up to complete weaning from the breast. The author was interested in defining cultural elements and aspects of social organization that interact with the feeding process and in identifying the consequences of this interaction for the child's growth.

To be included in the study, men or women had to be present in households visited in the village, and the infants in these households were being breastfed or just beginning to be weaned. Effort was made to include households distributed throughout the area, near the main roads or accessible only on foot, and with or without cattle. Structured interviews were carried out on three topics: food production, nourishment, and breastfeeding. The topic of breastfeeding was directed toward women and the other two involved men. A total of 114 mothers were interviewed. All interviews and most conversations were tape-recorded and transcribed. In addition to these interviews, Wagogo everyday life was studied by participant observation of farm work, stock-raising, domestic chores, preparation of meals, and child care.

Food type and age of introduction (what)

All infants participating in the study were under five years of age. The author reports that most infants started eating additional food between three and four months of age. The first traditional baby food was a thin soup of millet flour and water (*uji*). Occasionally, sugar or the milk of groundnut flour was added. As the child aged, the gruel was made thicker, and new ingredients were occasionally added to the millet flour and water, such as native fruits, wild roots, or finely ground nuts. If families had more cows, fresh milk mixed with sour milk would be used to cook the *uji*.

When the child was about one year old, it started to learn to eat *uwugali*. This thick porridge was the staple adult food and was always served with a side dish of some kind, generally a vegetable.

Regarding the quantities fed to babies, the women said, "Daily, you estimate a certain amount of food. If the child finishes his portion, you come to know that the amount is not enough and add to the quantity. If he eats and some food remains, you know that he is satisfied."

Food preparation and feeding style (how)

Uji was often eaten from a cup or a traditional gourd.

Caregivers (who)

Only when the baby could be fed other food (in addition to breastmilk) would the mother leave it at home with a baby-sitter (*mkoci*), a daughter, a young neighbor, or her mother-in-law.

Feeding frequency and schedules (when)

The author reported that, at first, the porridge would be given once a day. However, when a baby began to sit up on its own, additional *uji* was given to him or her more frequently and, by the second year, he or she would be fed the porridge two to three times a day.

Feeding environment (where)

According to the author, a woman's newborn baby was carried on her back throughout the day, held tightly in place by a piece of cloth. During the night, mother and baby slept together in the same bed or on the floor. If the mother worked in the field, she would take the baby with her.

Sociocultural determinants (why)

In the view of the older women who were interviewed in the Tanzanian study, young mothers today no longer cook *uji* in the traditional way, preparing *ubaga we zaliko,* a special baby food that is "good for growth." These women said, "Today nobody cooks the traditional infant food because it is a tiring job; women have got out of the habit of cooking it, and now this food is not agreeable to the infant's taste." The authors note that, although this special gruel was more palatable and considerably reduced the dietary bulk of cereal-based food, it called for a long preparation time:

the millet had to be pounded twice and then ground until it became a fine flour. This flour was poured into a pot, mixed with water, covered, and placed near the fire overnight. It was then cooked the next morning and water was added if necessary.

The child's perceived appetite marked the timing of the introduction of complementary food, and his actual age had little or no influence. The mothers said, "*Baby cries a lot because its stomach is growing and the breastmilk alone cannot satisfy its bigger appetite.*" Using the traditional language (Gogo), mothers explained that when milk can no longer "plaster" the stomach of the child, the child frequently feels hungry and cries. This was interpreted as a sign that the baby was grown up and that its stomach was strong enough to receive semisolid food. Women also thought it was necessary to create the desire for *uwugali* in the baby from its youth because *uwugali* would be its main source of nourishment when it was weaned. One mother said she started to prepare a liquid gruel when her baby was one month old as a measure of precaution. She wanted to have an alternative solution so that if she had health problems, her baby would already "know" another food as well as breastmilk.

The significance of the health services as part of the social support and social network influence is illustrated by the finding that mothers reported to the investigator that health-care workers in the community advised them to prepare *uji* with cow's milk, groundnut, egg, *dagaa* (dried fish), or oil.

Case study 3. Mali (urban squatter community) [48, 49]

Background

This research was conducted in Bamako, Mali, in 1982 and 1983. The study community, known as "Farima-bougou" (a pseudonym), was one of approximately 10 periurban squatter communities that have sprung up across the Niger River from the capital of Bamako. The sample population was composed of 136 infants (including 20 sibling pairs). To be eligible to participate in the study, the infants had to be (preferably) only breastfed at the beginning of the study, and the mothers had to be enthusiastic about participating. The women's homes were visited on a monthly or a bimonthly schedule. At the first visit, the child's health and dietary history were recorded, as well as data on ethnic background, family size and organization, father's occupation, and general socioeconomic status. In subsequent visits, data were collected on the child's anthropometry, stage of gross motor development, what the child was eating in general as well as what he or she had eaten in the past 24 hours, and the condition of his or her health since the previous visit. In addition to information on the child, data on the mother's health and whether she had had a menstrual period since the previous visit were collected. Structured and unstructured interviews

with mothers, coupled with observations of maternal–infant interactions, were used to supplement the data. The objective of this study was to provide a complete understanding of infant health in situations of rapid change by determining which beliefs were changing and which were resistant to change, and by identifying articulated beliefs that have persisted while actual practices have been altered.

Food type and age of introduction (what)

The author reports that, according to the women, water should be heated and given to the newborn baby every day from the day after birth. This warm water is thought to "open the baby's stomach." Mothers said that warm water should be given every day until the baby's skin color had changed from the lighter birth color to the permanent color, usually three to four months after birth. After this change, the baby could drink cold water if he or she was thirsty. In practice, however, most mothers did not give their infants any water at all until they were old enough to drink from a cup.

There were 92 children in the sample for whom data were available on when solid foods were first introduced. These children were in the age range of 3 to 24 months and over, with a mean of 7.9 months and a mode of 6 months. Most children began solid foods within a limited period, 80% from four to nine months of age. Only 9.8% of the children began solids after 12 months of age, and the mothers of all these children allowed them to decide when they wanted to begin to eat solid foods.

The first solid food was usually a breakfast porridge, either *moni* (made from millet), *seri* (made from rice), or *rui* (the liquid portion of *moni*). This first porridge was often given in conjunction with a variety of other foods considered "especially good and appropriate for babies." Fish and potatoes were the two foods that were most frequently mentioned in this regard.

Other foods sometimes given to very young children included Cérélac (a commercial French product made of infant formula and cereal), fruit (especially mangoes and bananas), eggs, coffee made with milk and sugar, and bread.

Food preparation and feeding style (how)

Most children started solid foods at about eight months of age by joining the family circle around the serving bowl at mealtimes, and, at the 4:30 p.m. meal, by being given a bowl of food. Children were expected to be responsible for feeding themselves, to eat until they were full, and then to stop eating once they were full. The idea of putting food directly into a child's mouth was not widely accepted or followed. Children, however, were taught the appropriate hand to use for eating, since, according to Muslim custom, eating with the left hand is unclean. In addition, they were taught

not to eat dirty objects or food items they found on the ground.

Caregivers (who)

Because children were responsible for feeding themselves, few caregivers watched them eat. For example, the author reports that two mothers of half-sisters could not say which one had eaten more at the 4:30 p.m. meal, since neither mother had watched them eat.

Food frequency and schedules (when)

In Farimabougou, food is "officially" provided for all members living in the compound three times each day, breakfast (5–7 a.m.), lunch (12–1 p.m.), and dinner (7–8 p.m.). In addition to these three meals, most young children also eat at around 4:30 p.m. The food consumed at this time usually consisted of leftovers from lunch, the women preparing extra food at noon so that there would be enough for this meal. If the child was still hungry when the food was finished, the mother would prepare *moni* or *seri* for him.

Feeding environment (where)

Food was made available at the child's level, on the ground, and children ate with their fingers out of a bowl on the ground.

Sociocultural determinants (why)

Because Farimabougou is located less than half a kilometer from the banks of the Niger River, fresh fish was always available in the daily market. It was slightly cheaper than meat, and was regarded as easy both for women to cook and for babies to eat. Potatoes, like fish, were readily available in the market, and they were seen as easy for the mother to prepare, and easy for a baby to chew.

Women perceived eating solid foods as another step toward becoming an adult, like walking or talking. Mothers did not try to establish an arbitrary time for beginning solid foods, just as they did not particularly encourage walking or talking. They often said, "When the child is ready, it will begin." Most babies began to eat solid foods when they were "old enough" by some general or specific criterion. According to the author, this might have been general development (perceived age, overall size), motor development (sitting up, crawling well), number of teeth (anywhere from two to eight was cited as a necessary prerequisite), or when they themselves wanted to eat. Both fish and potatoes were described as "light" foods, easy for a baby to chew and digest. Although meat, eggs, and liver were seldom given to infants, this was because of their relatively high cost, not because they were forbidden; they were considered "good" for babies, coming just after fish and potatoes as desirable supplements to breastmilk and porridge. According to the author, although there was not much variety in the diet, children still developed

certain food preferences, and women tried to accommodate to their infants' tastes, bringing and preparing foods they knew the baby liked to eat. However, some women did not accommodate their children's preferences, saying that babies had to learn to like what was available. The author noted the example of one child who did not like *to* (millet); whenever the family ate *to*, which was at least once a day, this child did not eat anything.

The women in the study generally believed that adult staples were not appropriate for very young children. Twelve months was cited as the age at which a child could safely begin to eat adult foods such as *kini* (rice) or *to* (millet), but many children in the sample actually began to eat these foods at a younger age, and some at an older age. Reported adverse consequences from eating *kini* and *to* too early included a big stomach, choking, frequent and/or copious defecation, trouble with digestion, delayed growth, delayed crawling, delayed walking, and general ill health. Several women explained that *kini* and *to* were "heavy foods" and were therefore not appropriate for a young child. Because the Malian mothers accepted lack of appetite as a normal part of many, if not all, childhood diseases, they did not make any effort to encourage or force a child who was ill to eat. There were no special foods for sick children, nor did mothers prepare favorite foods to tempt children to eat. There was a very strong belief that in sickness, as in health, a child would eat if he or she was hungry and should not be given food against his or her will.

In Mali fish is considered a traditional baby food, and women were reported to have said, "We give fish to our children because it is our tradition, because we have always done it, and because fish is good for babies to eat." According to the author, because almost all Malian women in the sample spent some time after delivery at the maternity clinic, the clinic personnel had ample opportunity to influence their beliefs and practices. The maternity nurses told mothers to introduce solids at 6 months, to wean girls at 18 months, and to wean boys at 24 months. According to one nurse, boys were inherently weaker and needed to nurse longer to be strong. The author also reported that the mean age at which children started eating solid foods was almost three months later for boys than for girls (9.8 vs. 7.1 months) and that most children who began solid foods after 12 months were male, reflecting the greater range of variation in introducing solid foods to the diet of boys.

Case study 4. Zimbabwe (rural villages) [50]
Background

This study was carried out in several adjacent villages in the Chivi District of Zimbabwe. The study was part of a larger interdisciplinary and collaborative project on the determinants of malnutrition, morbidity, and

mortality in a rural area of Zimbabwe. The objectives of this project were to document the pattern of infant and child feeding and to assess the nutritional status of children under five years of age.

The study was carried out in two phases. In the first phase, 800 women in seven villages in the study region were surveyed. All women were asked detailed questions concerning feeding practices and beliefs; 24-hour dietary intake data and weekly consumption lists for the children were collected; and anthropometric measurements were taken for each child under five years of age. Mothers aged 15 to 49 years were eligible. In the second (ethnographic) phase of the study, in-depth interviews were carried out on 55 women, a subset of women from the larger sample of 800. These women were pregnant during the first phase and had delivered by the time the second phase took place. To complement these in-depth interviews, child anthropometric measurements were taken; maternal and child 24-hour dietary intakes and weekly food frequencies were recorded; traditional healers, community health workers, and clinic personnel were interviewed; and observations were carried out at the clinic.

Food type and age of introduction (what)

The first supplemental food given to the infants was porridge or gruel (*bota*), which was most commonly made from maize mealie meal (a pap from ground corn meal) and was infrequently made from other grains, such as sorghum or millet. Salt, sugar, oil, margarine, or peanut butter (and rarely milk) was added to the porridge if it was available and affordable. Of the 55 mothers in the in-depth study, 70% said they had added sugar to the porridge and 43% said they had added peanut butter. The authors reported that they were not able to find out how frequently the women actually did this, since in the 24-hour dietary recall, only 47% specified that they had added sugar and only 29% had added peanut butter.

In addition to porridge, which is considered a soft food and thus "good for an infant," other supplementary foods included bananas, oranges, eggs, peanut butter, soup, and milk. These foods were said to be good for body-building and energy.

The age at which supplementation began varied widely. In the in-depth study, 68% of children under six months of age were being supplemented by three months of age. The authors noted that a difference existed between the age at which supplementation actually started and the expressed norm, with the age expressed as the norm being later than the actual age at which supplementation started.

Food preparation and feeding style (how)

Porridge was usually fed to the child from a cup or bowl with a spoon, or, occasionally, with the hand for a very young infant.

Caregivers (who)

Porridge was usually fed to the child by the mother or another caregiver.

Food frequency and schedules (when)

Food frequency and schedules were not discussed.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

The maize used for preparing porridge was generally from the family's own harvest and was ground at a mechanized grinding mill. If a woman did not have time to go to the grinding mill or was short of money, she would pound her own grain. Other grains grown by the women, such as bullrush millet, *rapoko* (finger millet), or sorghum, were not frequently used for porridge. Although they noted that sorghum and millet were nutritionally superior to maize, several mothers said that because these grains took more time and energy to grind and prepare than maize, they preferred to use maize.

The mothers frequently suggested that the child's crying or inadequate breastmilk production were the reasons for early supplementation. These two reasons were often complementary, since the primary indicator used by the mother for insufficient milk was the child's crying. Other reasons less frequently mentioned included that the child was old enough, "The child wanted it," or "It was good for the child." Not all foods, however, were considered good for supplementation. Foods that were thought to cause diarrhea in the child were primarily those that were difficult to chew or digest, such as boiled maize, groundnuts, round nuts, dried vegetables, and meat. Tea, especially with sugar, and sweets were also considered "bad" because they could cause diarrhea.

Geographic area: Latin America

Case study 5. Brazil (periurban shantytown) [51]

Background

A cross-sectional study was conducted on 133 mother-infant pairs (infants aged 0–12 months) in a shantytown 25 km outside Brasília, the capital city. This sample consisted of all infants in one sector of the shantytown, which had 17,000 inhabitants. The community has electricity, bus service to Brasília, and some public schools. There is no sewage system, and water is available only at public spigots. Limited government medical assistance is provided.

Two nurses trained in the use of standardized survey techniques and questionnaires interviewed each of the 133 mothers once. Data collected included 24-hour

recall data of the infant's food intake, the infant's health status, sanitary practices, and the family's demographic and socioeconomic status. Anthropometry provided data on the infants' weight-for-age, weight-for-height, and height-for-age.

Food type and age of introduction (what)

The infants' diets included local and family low-cost energy–protein foods in a proportion higher than that recommended by medical schools. Food supplementation to breastfeeding infants began at one to three months for most infants. The most common supplement offered in this period was commercial powdered milk (66% of infants). No information was available about what other foods were given during this period. Solid food was introduced to most infants after four months. Grain-based foods were most common, particularly cornstarch for infants under six months. Fruits and vegetables were given occasionally. Beans, bean broth, and several kinds of herb teas were given occasionally with grains and grain-based products. Except for certain cereals, very few of these foods are specific to Brazil's infant food market. Beans and rice formed the basic meal of a six-month-old child. The infants most often received smaller portions of the same food that was prepared for adults. Other foods mothers fed their infants included rice, bananas, bread, cream of rice, oranges, cow's milk, cassava flour, meat, macaroni, apples, neston flour, cremogena, coffee, cornstarch crackers, potatoes, cashew juice, eggs, cake, rice soup, cream of corn, tomatoes, squash, lettuce, and chicken. All infants received supplemental foods along with a type of milk or formula.

Food preparation and feeding style (how)

Food or drink was offered to the infant. Adult food was broken into small bits. The women had limited access to refrigeration, so they cooked and recooked foods, sometimes preparing the meal a day in advance.

Caregivers (who)

No mention was made of persons other than the mother providing food for the infant.

Feeding frequency and schedules (when)

Most infants were fed five to eight times per day during their first year of life. Herb teas or some other liquid or foods were offered every two to three hours to infants aged four months and under. Older infants were fed one main meal at midday. The most frequent foods given to infants were powdered milk, corn starch, rice, bananas, bread, cream of rice, beans, oranges, cow's milk, and cassava flour. Foods given at an intermediate frequency were meat, bean soup, macaroni, apples, neston flour, cremogena, coffee, corn starch crackers, potatoes, and teas. The foods given least frequently were rice products, cashew juice, pineapple juice,

lemon juice, passion fruit, eggs, cake, rice soup, cream of corn, tomatoes, squash, lettuce, and chicken. The infants received a small subset of these foods when the mothers began supplementing.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

The mothers liked to prepare foods that could be cooked on the stove while they worked on other household chores. Women who worked outside the home prepared foods a day in advance and then reheated it. The preferred foods were also those that offered no problems with chewing, swallowing, or digestion. Fifty-one percent of the mothers who mixed breastfeeding and bottle-feeding felt that their own milk was inadequate and that supplementation with cow's milk, formulas, or other foods seemed natural and reasonable to them. According to the mothers, financial constraints prevented them from being able to provide the quantity and quality of foods that they would have liked to give their infants. Rice, beans, and cassava flour were popular among poor mothers, because they were believed to have a long shelf-life, did not require refrigeration, and took a relatively long time to digest. Mothers often gave cheap crackers or inexpensive foods to the infant when they observed signs of hunger (crying), but vegetables and fruits were viewed as weak or insufficient foods.

Case study 6: Guatemala (rural villages) [52]

Background

A sample of 65 families with children under the age of five years from three villages in the Chiquimula Department of eastern Guatemala was studied. The villages had similar housing conditions, with one elementary school but no electricity, and were similar in the parents' educational levels and the type of work done by men and women. One child from each household was studied. In 40 households with more than one child under the age of five, a random process was used to select which child would participate in the study. A total of 41 mothers who had children over six months of age were interviewed. The subjects were participants in the Benson Institute Program and had similar standards of living as nonparticipants. The goal of the study was to identify the mothers' beliefs and attitudes related to feeding their children.

A baseline weight-for-age measure was collected. Anthropometry was used to classify children into two groups: normal weight ($\geq$ –2SD weight-for-age) ($N = 25$) and malnourished ($<$ –2SD weight-for-age) ($N = 31$), using the National Center for Health Statistics (NCHS) growth standards. The population was poor, and 48% of the children were malnourished. The proportion of normal to malnourished children

was similar in all villages; however, the children's nutritional status was not related to the availability of food in the home. The principal investigator spent two to three hours in each home on four visits to "talk with the mother, observe practices, and participate in the families' activities." Specific practices observed included frequency of lactation, additional foods given, and their approximate amounts, consistency, and frequency. The mothers were asked to describe the consistency of gruels and to show them to the principal investigator. The interviews centered on the mother's beliefs and attitudes relating to feeding their children. Focus groups served to explore the findings suggested by observation of the participants.

Food type and age of introduction (what)

The children began to receive nonbreastmilk foods at four to six months of age. At 24 months, they were considered ready to eat all household foods. Breastfeeding continued for an average of 15 months. Foods offered to children included cornmeal gruel, Incaparina gruel, eggs, and fruit juice. The cornmeal gruel and Incaparina gruel were less commonly given as weaning foods. More mothers of normal-weight children gave their children eggs (30%) and fruit juice (20%) than mothers of malnourished children. More mothers of malnourished children (30%) than mothers of normal-weight children offered coffee as a weaning food. All mothers of normal-weight children gave them softened tortilla and bean broth during weaning. After 24 months, the children began to participate in family meals and received one or two snacks of leftover foods from meals during the day. Even after 24 months, the malnourished children received mostly liquid and semisolid foods.

Food preparation and feeding style (how)

All food for the children was selected from food prepared for other family members, rather than making a special baby food. The infant was allowed to taste such food by the end of the fourth month and was given more after six months. Cornmeal gruel was more often fed by bottle to malnourished children than to normal-weight children and was prepared with more water for malnourished children. The only use of the bottle reported for normal-weight children was for cornmeal gruel. Most of the food fed to normal-weight children was thick, as compared with the thin consistency of food fed to malnourished children. The mothers of normal-weight children gave broth with some thick food. The mothers of malnourished children gave broth alone. The youngest children were not given all of the kinds of food eaten by the family.

Caregivers (who)

Only mothers were described as providing food to their children. This area was not explored by the authors.

Feeding frequency and schedules (when)

Normal-weight children were fed three times a day when they were 7 to 12 months of age and five times a day when they were 13 to 24 months of age. In contrast, all malnourished children aged 7 to 12 months were fed only once or twice a day, and 72% of malnourished children aged 13 to 24 months were fed two or three times a day; 66% of malnourished children over 24 months of age received food three or fewer times a day and participated in two or three family meals.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

Some mothers of malnourished children said that they used bottles because they were concerned about the amount of work they had, and bottle-feeding saved time. These mothers fed children infrequently because they said that they did not have time to feed them more often, and also because the children did not ask for food. Many mothers of normal-weight children said that they used bottles occasionally because they felt that the children needed to eat something while their mothers were engaged in chores outside the home.

All mothers believed that children younger than 24 months were not ready for significant amounts of family foods. Although the mothers considered broth a nutritious food, they stated that "children need thick food to meet their needs" and "liquids alone are not good for them." Earlier studies in the region reported that meat and whole beans were not given until the children had teeth because these foods are viewed as "heavy." Avoiding them was thought to prevent illness. Calorie- and protein-dense foods were seen as adult foods and were given only if the child asked for them or at the mother's initiative.

The mothers of normal-weight children reported having in mind a specific amount of food that children should eat. They also recognized that children needed special care and commonly said that "if children do not eat enough during the weaning period, they will lose weight and it will be hard to gain it again." Most of these mothers (66%) felt responsible for determining how much food their children should eat, even after the child reached two years of age. Most (82%) also demonstrated a positive attitude toward their children and expressed specific aspirations for life and willingness to improve or maintain their children's well-being. Some said that they wanted their children to be better than themselves and that they would do anything to make sure their children had a better life. The mothers of malnourished children, however, did not seem to be aware of the relationship between their children's poor health and inadequate bottle feedings. Some of the mothers felt that "children are so small, so they need to eat less often," and "if they eat too much they can get

sick." They said that "children know exactly how much to eat," "they will ask for food when they are hungry," and "they can get used to eating a lot" (implying more work for the mother). These mothers also said that "infants are not ready to eat semisolid food" and "liquids such as broth are very good food." Only 20% of them visualized a specific amount of food to feed their children. The authors noted that most of these mothers (80%) expressed fatalistic, unhappy, or conformist views. They said, "Such is life and we can't do anything about it (*asi es la vida*)."

Case study 7. Peru (rural and urban highlands) [20, 53, 54]

Background

Multiple studies were carried out in three villages of the Callejon de Hauylas region of Peru as part of the larger Dietary Management of Diarrhea Project. The region is a 270-km-long highland valley, 1,500 to 4,000 m above sea level and 400 km northeast of Lima, with serious deforestation and erosion of the surrounding hillsides. There are approximately 100,000 people living in the valley. Most villagers own some land and work primarily in agriculture. Women contribute to both agricultural and domestic work but rarely work in the formal market sector. Two villages were in rural areas, and one was urban. A variety of ethnographic and participatory methods were used to develop a culturally appropriate weaning food, *Sanquito.*

Foods and timing of introduction (what)

Rural. The infants received the majority of their calories during the first 12 months from breastmilk and were breastfed for at least two years. After about six to eight months, wheat and potato soups (*sopas*) were commonly introduced. These soups were the standard component of the adult Indian *campesino* diet. Some infants were fed sweetened wheat porridge.

Urban. Solids tended to enter the diet earlier for urban infants, and the variety of food was greater than that for rural areas for all age ranges. No special foods were given by either group during diarrhea, but herbal teas and remedies were commonly fed to infants. Breastfeeding continued during diarrhea. ORS (oral rehydration solution) was given in a small percentage (5%) of episodes of diarrhea and soup in 25% of episodes. Foods given to children aged zero to 12 months included herbal teas, ORS, soups with solids, soups with broth only, dry cereal, *mazamorra* (cooked corn cereal), bread, tubers, meat, fish, eggs, fruit, milk, liquid cereals, vegetables, fats, and oils. In the rural villages, the energy density and micronutrient content of the weaning diet were low because the diet consisted primarily of the broth of the family soup, in addition to breastmilk.

Feeding style (how)

When children were healthy or convalescing, the mothers exhibited passive feeding behavior, i.e., very little physical help or verbal encouragement was provided to the children during the meal, even if the caregiver was physically present. When children were ill, some mothers altered their feeding style by offering special foods and verbal and physical encouragement to eat. The caregivers voiced concern about lack of appetite during illness, and this explains their more active feeding style in response to diarrheal or respiratory infection. When the children's appetites had recovered (after the symptoms had abated), the caregivers were no longer concerned, and they lacked knowledge of the importance of active feeding to maximize the dietary intake of their young children. Ethno-theories help explain some of these practices, such as the need for children to learn how to survive, grab their own food, and become tough and resilient.

Caregivers (who)

Mothers fed the children in more than 70% of episodes. Older siblings often fed the children, and fathers rarely fed them.

Frequency and scheduling of feeds (when)

Children received their main meal about noontime, and consumed very little in the afternoon and evening. Some mothers reported feeding more frequently during episodes of diarrhea.

Feeding environment (where)

Children ate in the home, usually in the area near the stove or cooking fire.

Sociocultural determinants (why)

Diarrhea episodes were characterized as "hot" or "cold," and the remedy had to have the opposing property to reestablish balance. Herbal remedies were given to counteract the hot or cold qualities of the condition. The mothers restricted certain foods during diarrhea in the interests of their children's health. Potatoes were not given because they were considered hot and therefore harmful during diarrhea. Beans were also considered harmful. Potatoes and beans were viewed as harmful because they were seen as "heavy" foods leading to stomach irritation and an increase in diarrhea. However, the mothers often said that children with diarrhea could eat *cualquier cosa* (whatever they wanted). Many believed that children's appetites decreased during diarrhea. Urban mothers were more concerned with reducing the amount of food children ate during diarrhea, whereas rural mothers emphasized humoral causes of diarrhea. Urban mothers withheld fried foods, which were seen as harmful. The mothers explained the increase in breastfeeding frequency during diarrhea as due to the decreased appetite the

child had for solid foods. Child appetite was a central concern of most mothers. Although mothers are the primary caregivers for their children, they are also most often the one to provide care when the child is ill. In one study, special foods were prepared specifically for children more often during diarrhea than when the child was healthy.

Potatoes, which were classified as harmful (heavy) when defined as a broad food category, were considered slightly more acceptable when fried and much more acceptable when mashed. Oil, considered warm in the humoral system, was considered to transform potatoes from the harmful *fresca* (cool) state to *templado* (warm). Wheat, reportedly consumed by two-thirds of children within the previous 24 hours, was claimed by 95% of mothers to be harmful when fed during diarrhea. However, it was found that some preparations were acceptable for feeding during diarrhea. The most unacceptable form of wheat for children with diarrhea was the whole-grain form. Toasting converted *fresca* to *calido* (hot) and improved its perceived quality. When wheat was both toasted and ground into flour, it was considered most appropriate for children with diarrhea and was reported to be a "helpful" or "good" food. Toasted wheat flour was the only staple food preparation that fell into this category.

Legumes were considered harmful (because of their heaviness) during diarrhea when they were served fresh, dried, or boiled. As with wheat, however, legumes were considered acceptable when they were toasted and then ground into flour. Among the available legumes, peas appeared to be more generally acceptable than beans. Carrots were believed to be bad in the raw state, but the majority of women considered them safe when cooked.

Case study 8. Dominican Republic (urban neighborhoods) [55]

Background

Research was conducted from August through December 1989 on a random sample of 103 children aged three years and under and their caregivers from three communities in the Los Alcarrizos sector of Santo Domingo. Almost 95% of the caregivers were mothers; the remainder were grandmothers, stepmothers, or sisters. Two mothers were Haitian and the rest were Dominican. The mothers tended to be young and had only basic formal education. Twelve percent of the mothers worked outside the home. Most had only been in the urban environment for two and a half years. These neighborhoods were chosen because the two nutritional rehabilitation centers in Los Alcarrizos had more malnourished children than centers in other local neighborhoods. The goal of the study was "to identify community-specific deficits in infant feeding practices in order to determine target issues for local

health education interventions," which were based on generalized guidelines.

Local Health Promoters who were members of the community researched and administered the questionnaires. All interviewers were trained at a local medical center and were familiar with the local language and customs. Questions were designed to elicit information about infant feeding practices, as well as the socioeconomic and environmental conditions of the respondents. Anthropometric measurements were taken at the conclusion of the interview to assess the nutritional status of the children. Stunting was determined to be the most severe growth deficit. The average birthweights were at approximately the 50th percentile of the NCHS values. Malnutrition was viewed by the researchers predominantly as a postpartum event. Additional questions were added to the interview midstream, and time was not available to return to previous respondents. Responders to the new questions are designated as subgroup B.

Food type and age of introduction (what)

Ninety-five percent of the mothers initiated breastfeeding, and they continued for a median duration of 7.5 months. One-third of the mothers stopped nursing by three months. The mothers in subgroup B breastfed their previous children for a mean duration of 1.1 years. Nonbreastmilk is commonly used in these communities, despite its cost. Almost a quarter of all mothers introduced alternative milk sources in the first week after birth. By three months, half of all mothers had given other milks. Inespre, a non-infant-formula milk powder, was the most commonly reported product used. The most common weaning items reported were orange juice, lime juice, and beans (40% of all mothers). Others reported giving potatoes, *auyumas* (an orange-yellow squash), spaghetti or noodles, rice, and plantains as first foods. The median age of introduction of various food groups was reported for 100 of 103 infants, according to the Canadian Food Guide: first nonmilk food at 3 months, fruits and vegetables at 3.2 months, oil or butter at 3.9 months, meat and alternatives at 4.1 months, and breads and cereals at 4.6 months. Teas and fruit juices were fed by bottle early in life. For children over one year old, milk, beans, rice, and citrus fruits were consumed regularly although not daily.

Food preparation and feeding style (how)

Some mothers diluted the milk, others did not. Seventy percent of the mothers prepared the milk prior to family meals, and 30% stored the prepared milk for later feeds. Some milk was stored for up to half a day. The infants were fed portions of the adult diet as purees of single foods rather than receiving a specific weaning diet. Seventy-six percent of the mothers used bottles to feed milk or juice. Virtually all mothers

claimed that they washed the bottles in boiling or bottled water. The mean age at which bottle-feeding began was seven weeks. The median, however, was three days. Many mothers started infants on formula at birth on their own or the hospital staff's initiative. The caregivers claimed that they washed their hands before food preparation and washed the infants' hands before a feeding. Snacks were allowed, but children's hands were rarely washed beforehand. Forty-four percent of all mothers said that they covered and stored the food after it was prepared; however, because of malfunctioning refrigerators, this was not always as protective as it could have been.

Caregivers (who)

Mothers were described as the primary caregivers. No other information was provided.

Feeding frequency and schedules (when)

Information was not available about feeding frequency for children under one year of age. Food-frequency data were given for children aged one to three years in terms of the frequency of certain food groups *not* consumed regularly. Regularly was defined as once a day for "meats and alternatives," as well as for breads and cereals, and twice a day for fruits and vegetables. Among 34 children aged one to two years, 18% did not consume meats and alternatives regularly, 7% did not consume fruits and vegetables regularly, and 4% did not consume breads and cereals regularly. Among 30 children aged two to three years, 13% did not consume meat and alternatives regularly, 10% did not consume fruits and vegetables regularly, and 3% did not consume breads and cereals regularly.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

A reason mothers gave for early termination of exclusive breastfeeding was that they had been separated from the child for periods of time, sometimes due to work commitments outside the home (16.9%). Although many women did not have functioning refrigerators, they prepared powdered milk ahead of time (30%) and covered and stored it for later feeds, sometimes for half a day.

Mothers who suspended exclusive breastfeeding early commonly reported that they had insufficient milk or that they had "dried up" (53.2%). Mothers who were taking medications, either antibiotics or birth control pills, also commenced weaning (7.8%). In this study, some mothers terminated exclusive breastfeeding when it was considered time to begin feeding nonbreastmilk foods (6.5%). Some mothers overdiluted the powdered milk to extend it (14%), and they occasionally underdiluted it to provide a more concentrated meal (10%).

Those who overdiluted and underdiluted tended to be the same mothers. A few mothers reported that the reason for adding complementary foods to their infant's diet was because someone else (not the mother) deemed it necessary (3.9%).

Geographic area: Asia

Case study 9. Bhutan (Wamrong Subdistrict, East Bhutan) [56]

Background

A total of 98 mothers at 30 to 36 months postpartum from the Tibetan culture of Wamrong Subdistrict, East Bhutan, participated in a study to examine the relationship between breastfeeding and subsequent pregnancy. The women lived in villages of more than 18 houses, and the subdistrict had a total population of 13,487 in 1992. Most of the inhabitants lived in narrow valleys and practiced subsistence agriculture. The main crop was maize. Lama-Buddhism was the national religion, but it was mixed with the ancient, animistic Bon religion, particularly among more traditional inhabitants. The region was considered typical of east Bhutan but was slightly poorer and had less infrastructure. Communication was difficult.

The interviews were conducted by local women who were not health workers and were taught interview techniques by the researchers. One of the researchers was present at each interview, but for cultural reasons the researcher did not take part in the discussion. The questions were piloted and revised. One of the women interviewed while another took notes. Men of the household were never present. The fact that the interviewers were all women of the same culture, religion, and language group as the population and were not health workers created the necessary environment for discussion of sensitive topics.

Food type and age of introduction (what)

The duration of breastfeeding averaged 26.8 months (median, 28.0 months). Colostrum was often discarded until it became white. Virtually all women fed their babies with small amounts of butter and flour in the first three days of life. Sick children also received these foods. Daily supplementation with semisolid foods was initiated after two months. The children ate adult foods after an average of 11.2 months. Maize was the staple diet. The median age of introduction of semisolid supplements was three months. The first semisolid supplemental foods fed to infants were rice flour–based porridge (61%), maize (6%), or a mixture of the two grains (8%). Vegetable oil and water were used in the preparation of foods. Eggs were introduced one to two months after the initial semisolids. Weanlings seldom received fruits or vegetables. Approximately 20% of

children were fed commercial baby food. Night feed-ing continued until sevrage.

Food preparation and feeding style (how)

The infants were breastfed and received their first semisolids in small amounts. The rice flour porridge was prepared by mixing flour with butter or a local vegetable oil, frying it, and then adding water to make the porridge. The mother carried the child on her back much of the day and slept with the child until it was one year old.

Caregivers (who)

Only information about mothers was provided.

Food frequency and schedules (when)

Breastfeeding occurred on demand during the day and night. Supplemental feeding with semisolid foods occurred daily after two months. No information was provided about daily routines.

Feeding environment (where)

The children were nursed at night on the floor, where they slept with their mothers. No information was available about the environment of daytime feeding.

Sociocultural determinants (why)

Colostrum was discarded until it was white because it was viewed as "rotten." The majority of mothers (65%) viewed concurrent lactation and pregnancy as detrimental to the breastfed child, 19% considered it beneficial, and the remainder (16%) did not express an opinion. Women who viewed concurrent lactation and pregnancy as detrimental tended to have a slightly shorter duration of concurrent practices than the other respondents, but the difference was not statisti-cally significant. When asked about this discrepancy, most mothers responded that "the child was not willing to stop," and others answered that they had not been sure that they were pregnant until the fetus began to move. It was believed that a new pregnancy would cause breastmilk to "rot" and become harmful to the breastfed child. When a mother experienced conflict between her desire to stop breastfeeding and the child's desire to continue, the child's will was given priority. When children were ill, they were fed a special food of flour and butter.

Case study 10. Bangladesh (rural villages) [57]

Background

From February to July 1986, 185 infants and children aged 4 to 27 months (98% of the eligible child popu-lation) were studied to examine how maternal and household education levels affected infant and child feeding practices. The study was carried out in four villages in a rural lowland area 60 miles west of Dhaka.

Transport and communication are difficult in the area, which has complicated the efforts of the nation's devel-oping health, education, and social services network.

A census of socioeconomic and demographic data was conducted first with the head (or other responsible adult) in all participating households. Over half of all households derived their income from insecure day and seasonal labor, and 75% of women and 51% of men had no formal schooling. Two scales were developed as proxies for household income: one for household wealth and one for agricultural resources. Spot and event observations followed once a week for each mother–child pair. In spot observations, the condi-tions surrounding the child at the time the investiga-tor entered the house courtyard were recorded. Event observations entailed 45 minutes of note-taking by the investigator positioned unobtrusively in the courtyard. Of the 24 attempted visits per pair, the investigators completed a mean of 22 when the child was present and awake. Data were collected at the participants' homes by trained investigators from the local villages. Partial correlations and stepwise multiple regression analyses were used to examine relationships between observational data and census data.

Food type and age of introduction (what)

All children were observed breastfeeding, and only 14 of the 185 were weaned by the end of the six-month study period. Supplementary foods given to children included finger foods or snacks in dry pieces (36%), rice or foods with a ricelike texture (35%), soft and wet puddings or porridges (8%), bottles (12%), and liquids (9%). None of the children received rice or wheat meals in age-appropriate quantities. Most feedings of finger foods were too small to be considered a meal or to meet nutritional needs.

Food preparation and feeding style (how)

Solids and semisolids were prepared in a variety of ways, as noted above. Based on feeding observations, two-thirds (66%) of the children were fed with the caregiver's hands, whereas 14% of children ate with their own hands. Various utensils were used for feeding, such as bottles (12%), local shell spoons (4%), regular spoons (3%), and cups (1%). Bangladeshi adults usu-ally eat with their hands.

Caregivers (who)

The prevailing cultural norms and lack of income-earning opportunities result in rural women being confined to the home compound. All but 6 of the 185 mothers claimed to be housewives, and in two-thirds of all observations the mother was the child's caregiver. In the observations of eating, the investigators noted that the infant or child was fed by the mother (55%), another woman (18%), a child under 16 years old (9%), no one (12%), or an adult male (5%). Breast-

feeding could take place while the mother performed other functions, such as leisure (61%) or economic (13%) activity, cooking (10%), meal preparation and household maintenance (9%), child care or play (5%), and eating (2%).

Food frequency and schedules (when)

Because of the large quantities of data reported, information will be presented on infants aged 4 to 12 months. Infants aged four to six months (164 observations) breastfed a mean of 1.15 times per hour and ate supplementary foods 0.35 times per hour. Those aged seven to nine months (503 observations) breastfed 1.07 times per hour and ate supplementary foods 0.37 times per hour. Those aged 10 to 12 months (585 observations) breastfed a mean of 0.93 times per hour and ate supplementary foods 0.46 times per hour.

Feeding environment (where)

The location of feeding was reported for all infants and children, without a breakdown by age. Breastfeeding was observed on an open porch (35%), outside at a neighbor's home (30%), inside the house (28%), in the courtyard (3%), and in other unspecified sites (2%). Eating was observed inside the house (40%), in the courtyard (27%), on the open porch (27%), outside at a neighbor's house (2%), or in another location (1%). Of all the child-feeding observations, 45% occurred on an earth surface, 26% in the arms of the caregiver, 11% on a mat, sack, or cloth, 11% in a small chair, and 8% on a bed.

Sociocultural determinants (why)

Mothers with more education tended to take more time out from work to feed their children than the less educated mothers. Being in a wealthier household may have resulted in fewer time constraints on child feeding and more leisure time for feeding. The quantitative analysis showed that mothers who breastfed their children and engaged in economic activities tended to be unschooled ($r = 0.17$; $p < .05$), to be less wealthy ($r = 0.14$; $p < .05$), and to have female children ($r = 0.15$; $p < .05$). In contrast, mothers who breastfed but were not employed were more likely to have attended school ($r = 0.22$; $p < .01$), to have educated husbands ($r = 0.15$; $p < .05$), to be nursing a boy ($r = 0.19$; $p < .05$), and to be nursing a child of lower birth order ($r = –0.22$; $p < .01$).

The belief component was examined almost exclusively in terms of education and through quantitative analyses that document a significant association between education and feeding practices. Mothers with more education fed their children in more protected, cleaner locations with fewer distractions where they could have more control over the child's meal. Educated mothers were more likely to feed the child on a bed, rather than on an earth surface. Being fed at a neighbor's home was also associated with having an educated mother ($r = 0.29$; $p < .01$), having a younger mother ($r = .19$; $p < .05$), and being of lower birth order ($r = –0.14$; $p < .1$).

Other examples of associations between education and feeding practices included the total number of eating events per hour (excluding breastfeeding) and the total number of bottle-feedings per hour, which were greater for children of educated mothers. Children receiving more total feedings (nonbreast) per hour tended to be older ($r = 0.35$; $p < .01$) and to have educated mothers ($r = 0.33$; $p < .01$). The number of total feedings showed a similar association with household education and with the child's age ($r = 0.29$; $p < .05$). Maternal education was positively and significantly correlated with the total number of observed finger-food feedings per hour and the number of nonbottle liquids fed to the child each hour. A greater number of finger-food feedings per hour was associated with being an older child ($r = 0.47$; $p < .01$) and having an educated mother ($r = 0.17$; $p < .05$). Children given bottles were more likely to have an educated mother ($r = 0.16$; $p < .05$), to be younger ($r = 0.34$; $p < .01$), and to be of lower birth order ($r = 0.13$; $p < .1$). Children who were fed by a child under 16 years old were more likely to have an educated mother ($r = 0.21$; $p < .05$) and to be of higher birth order ($r = 0.45$; $p < .01$).

Gender differences in feeding practices were also noted. Children fed on an open porch were more likely to have an unschooled mother ($r = .24$; $p < .01$), to be female ($r = 0.15$; $p < .05$), to be older ($r = 0.15$; $p < .05$), to be from a less wealthy family ($r = –0.23$; $p < .01$), and to be from an agriculturally less wealthy family ($r = 0.14$; $p < .1$).

Children who were fed with a cup were more likely to have an educated mother ($r = 0.28$; $p < .01$), to be male ($r = 0.14$; $p < .1$), and to be from a generally wealthier family ($r = 0.22$; $p < .05$) but an agriculturally less wealthy family ($r = 0.32$; $p < .05$). At the same time, boys were more likely than girls to be fed while the mother was at leisure, which suggests differential attention to child care based on the child's gender.

The authors posit that the decline in breastfeeding frequency may be related to the more modern attitudes common among educated mothers, which include the perception that food fed in bottles is good. Food fed in bottles may also be a status symbol.

Case study 11. Nepal (rural mountain area) [58]

Background

Field research was conducted from September 1982 through April 1984 in Humla, a mountainous district of northwestern Nepal, to examine the relationship between women's work and child care. The author describes Humla, one of the poorest regions in the country, as follows: "Development programs have

bypassed the region, agricultural techniques remain primitive, failed harvests and famines are frequent, and even in good years, poor families suffer hunger in pre-harvest months" [58, p. 231]. It is common for men to seek work outside the district in seasonal labor or trade. Women bear an average of 7.5 children over their reproductive years and also participate in productive labor to support the household. The region is home to three ethnic groups: Hindu Parbatiyas (mostly high caste), ethnic Tibetans (Buddhist), and Bura (of diverse ancestry, including Tibetans, local Hindus, and the Byansis of Darchula, but at present mostly Hindu Nepalis). The Parbatiyas farm in the lower valleys, the Tibetans in the higher valleys, and the Bura in the middle elevations. Despite their cultural differences, the division of labor between the sexes is similar in all groups. Both men and women participate in agricultural work. Women tend to do the majority of food processing and domestic work, and their time availability depends on the resources present for the household, because gender work roles are quite fixed. If the resources that a woman must provide are in short supply, it is her responsibility to meet the need, irrespective of other demands on her time or the demands on the males in the household.

Infant feeding was studied in six communities of Humla using a formal questionnaire. All three ethnic groups were represented. Households in the three communities were interviewed. In the two large communities, the households were selected at random; in the remaining smaller communities, all households were included.

Food type and age of introduction (what)

Early supplementation with nonhuman milk and foods is common, beginning in the first few weeks after birth. The Hindu babies' first food at the age of three weeks consists of rice in a mash mixed with water. According to Levine [58], most mothers then resume "full" breastfeeding. No other ethnic distinction was found with regard to the timing of supplementation. Women offered cereal to supplement breastmilk. Many women also gave a supplement to their children after six months of age. Some delayed introducing solids for over a year. Regardless of work demands, sevrage occurred late among all groups, commonly after the age of two years. Last-born children were breastfed quite long, some up to eight years.

Food preparation and feeding style (how)

Women prepared supplemental foods for children by masticating some of the grains designated for family members. This mash was then mixed with butter or untreated water. The food was left near the fire indoors or in the sun outdoors, where it attracted houseflies. The caregivers scooped small amounts of this mash out of its container with their fingers to feed the chil-

dren. Women employed various measures to wean the children. First, they tried to discourage the child verbally. Some then put bitter substances on their breasts. Others sent children to live with their grandmothers. One Tibetan community weaned abruptly.

Caregivers (who)

Child care was principally the mother's responsibility. Substitute caregivers became involved when women left the house for other work responsibilities. Other family members generally accepted this task. Sometimes children were left all day with alternative caregivers.

Food frequency and schedules (when)

Whenever they were at home, the women fed their children at regular intervals and on demand. They slept with their infants and small children, who were permitted to suckle freely at night. Women fed infants before going to work in the morning, at midday if they could return from their work outside the home, and immediately upon their return at the end of the day.

Feeding environment (where)

Most women fed the children at home, although a few took their children with them to the fields.

Sociocultural determinants (why)

Women felt constrained by their competing roles of caregiver and field laborer. In the winter, women stayed at home more because work demands were reduced outside the home and they could breastfeed longer than in the warmer months. During other seasons, women normally worked long uninterrupted hours away from the home in intensive agricultural tasks. The agricultural lands were located on rough terrain, which was difficult to reach and often required traveling along dangerous trails. A mother could either choose to stay at home with a nursing infant and neglect the agricultural work; take the infant with her to the fields, which resulted in less productive work and possible danger to the infant; or leave the child at home in the care of others. Women did not like to leave children in the care of others all day, even though this might be necessary for their work, because they believed that breastmilk would spoil during the day in the hot sun. Women from one community tended to bring their children with them to the fields, but this was attributed to the fact that the land was less rugged and transport less strenuous. These women also supplemented breastfeeding early, but because the land was more productive overall, their labor demands were less than those who lived in more rugged environments.

Women tended to begin supplements just before a demanding time in the agricultural calendar. The amount of wealth a household had was an important determinant of whether the woman could hire a substitute laborer and free herself from work in the

fields. Most women chose to leave the child with other household members, especially sisters, or good friends in other households. What a woman chose to do was dependent upon whether the household needed her labor and whether there were other children or responsible adults to care for the child. The difficulties of transport on the rough Himalayan terrain and working while caring for a child discouraged many from bringing their infants along with them during the day.

Mothers who chose to return to work soon after childbirth (in the first two weeks postpartum) usually left their children behind with substitute caregivers who were allowed to give nonbreastmilk foods. The seasonality of crop production also affected infant care. Agricultural work was treated as an inflexible component of a woman's work, whereas child care was simpler and manageable even by children. Women reported that they gave their infants cereals earlier than they would have liked because they had too many other work demands. Breastfeeding was considered a sign of affluence, because these women could choose to stay at home and provide child care and not go to work in the fields. Women who delayed introducing solids also tended to be wealthier, with enough economic security not to have to work in the fields.

It was commonly believed that "it is mystically dangerous to take vulnerable infants on public roads through lonely places, which were the supposed haunts of demons and ghosts." Women had varying beliefs about the optimal time to supplement breastmilk. Some mothers believed that early supplementation benefited the child and helped it to grow and become strong. Women would breastfeed as long as the milk was available because it was considered a woman's obligation, as well as beneficial both physically and emotionally, and carried no direct financial cost.

Mothers reported that when their diet was insufficient, their breastmilk also became insufficient and could not satisfy their infants' hunger. This was a common reason for introducing solid foods, second only to the women's work demands. Women also considered their own health status when deciding the timing for supplementation of breastmilk. Illness was considered a factor outside the woman's control that might lead to early supplementation. Many women said that they learned about early supplementation of infants from people in a neighboring ethnic group.

Case study 12. Philippines (periurban Manila) [59]

Background

A sample of 100 women from low-income households from five villages in Muntinlupa, an administrative district located 25 km from Manila, was interviewed. Sociodemographic information was similar for all the women, regardless of their village, because of the socioeconomic criterion for selection. The vast majority of

the respondents were "squatters" who lived, usually without permission, on someone else's land in makeshift houses of natural materials, carton boards, and canvas. These one-room homes were built in clusters with narrow alleyways for passage. There was no sewage system or garbage collection. The respondents collected water from communal taps or tubewells; 80% of the sources were potable. Half of the homes sheltered a nuclear family unit, while the rest included members of the extended family. Men and women had similar levels of education, most through the elementary level and some with a few years of high school. Household incomes were not adequate to meet basic needs.

The respondents were participants in the Infant Feeding Intervention Study (IFIS), a randomized, controlled trial using health education to promote breastfeeding and improved weaning practices from 1985 through 1991. Mothers were recruited in their second or third trimesters of pregnancy and included if the infants were healthy singletons weighing at least 2.2 kg at birth. The mothers and their children were followed for one year. Data were collected by formal ethnographic techniques, including in-depth interviews and extended observations, among others.

Food type and age of introduction (what)

Approximately 85% of the mothers initiated breastfeeding. At one year, half the infants still received breastmilk. Artificial milk feeding was widespread. In the first months of life, formula was given to infants, but as they grew, poorer-quality milks such as diluted condensed or evaporated milk replaced formula. Sugared water and rice water also entered the diet as milk substitutes. The introduction of solids occurred between three and six months, although some mothers began supplementation much earlier. Weaning foods included *lugao* (rice porridge), mashed fruits or vegetables (usually bananas or *kalabasa*, a type of squash), soft breads, and biscuits. By 12 months of age, the infants typically received multiple meals. Breastfeeding and bottle-feeding were commonly reported.

Food preparation and feeding style (how)

Virtually all mothers breastfed. Oil had to be cooked together with the food, rather than added later to precooked food. The foods were mashed or prepared to be soft for easy consumption by the child. The women also fed their children using bottles.

Caregivers (who)

Household members shared child-care duties, particularly when the mother needed to go to work outside the home or attend to errands. During the first few weeks postpartum, traditional birth attendants (*hilots*) aided with child care.

Food frequency and schedules (when)

The infants were fed two or three times a day by the time they were 12 months old.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

Child care was considered very time-consuming by the mothers—*ubos ang oras mo* ("Your time is used up")—because it was principally the mother's responsibility. Mothers of younger children scheduled their workday around infant care, and women were reported to have said, "I can attend to my sewing only after I am done with the children."

It was widely believed that a woman should not breastfeed her child when she was tired or angry or had just come in from the rain or the sun. The concern was that she might transfer her condition to the child, causing the child to become "fretful." The mothers believed that the breastmilk became hot in the sun and cold in the rain and caused *kabag* (colic) or diarrhea. Feeding an infant in the late afternoon or night was considered improper because *hindi matutunawan* ("he cannot digest the food") and the child was at risk of getting *impatso* (a stomach condition associated with undigested food and persistent crying). *Impatso* may also result from the consumption of food with oil added after it has been cooked. Likewise, fibrous fruits and vegetables, such as pineapple and corn, were not fed because they were considered difficult to digest and could cause *impatso.* Mothers with sore nipples were encouraged to continue breastfeeding because a child's saliva was believed to possess healing powers. Mothers perceived that male children were more active and had greater appetites than females, whereas females were viewed as being of greater use around the house and more affectionate. These beliefs affected infant care, in that boys were given more freedom to move about while girls were more protected.

Geographic area: Oceania

Case study 13. Papua New Guinea (rural village in Usino) [60]

Background

This study was carried out in Usino, Papua New Guinea, from June 1974 to July 1975, with a second period of fieldwork from July to August 1981. The study population was rural and "marginally modernized." In addition to interviews with adult men and women of the community, the ethnographer also interviewed government officials, teachers, clergy, and health workers. Through the identification of specific interrelationships between local economics, social structure, and features of the physical environment, the investigator sought to describe infant-feeding patterns in Usino within their larger sociocultural context.

Food type and age of introduction (what)

The types of supplemental fluids that were given to young infants included water, vegetable broth (mainly for sick children), and sugar cane sucked from the peeled stalk. If no problems were experienced with lactation, most mothers introduced broth and mashed papaya, sweet potato, pumpkin, and banana between six months and one year. The type of food introduced largely depended upon seasonal availability and convenience. Women claimed that their babies ate everything; however, close observation revealed that none of them fed their infants taro or meat until they were nearly a year old. Taro, like meat, was considered too strong for infants, and some of the women said it caused bloated stomachs.

Parents of sick children sometimes purchased canned or powdered milk from the patrol post stores. However, such purchases were infrequent because, in addition to the parents' lack of cash, the stores were infrequently stocked and were a two- to four-hour walk from the hamlets. A health center sporadically supplied infant formula to malnourished babies, but few Usino mothers undertook the time-consuming trip, citing lack of money as the cause for their reluctance.

Food preparation and feeding style (how)

Supplemental fluids were given to nurslings by a cup, bowl, or bamboo tube. According to the author, there was no bottle-feeding in the region, and if bottles had been available few Usino women could have afforded them.

Caregivers (who)

Mothers had the primary child-care role. The author reported that a mother would not regularly leave a nursling in the care of others in order to attend to other work until the child was eating supplementary semisolids and was crawling.

Food frequency and schedules (when)

According to the author, infants were fed on demand, as signaled by their restlessness or fussing. The breast was frequently offered to soothe or distract an upset child and was withdrawn when the child was calmed. Not all feedings resulted in a significant intake of milk, but over the course of the day, a child would suckle many times. However, although children often slept with their mothers at night, few mothers breastfed upon retiring for the night.

Feeding environment (where)

The infants accompanied their mothers everywhere in a net bag: to the gardens (where the women would sling

them on their backs while they worked, suspend them from tree branches, or ask other children to watch over them), to other villages, or to the patrol post.

Sociocultural determinants (why)

Women's work was generally compatible with breast-feeding and child care. The classificatory kinship system, with its patterns of marriage and postmarital residence, ensured that each child had several "mothers" who could be expected to share responsibility for it. While the infant required the mother's attention for regular breastfeeding, small tasks such as collecting firewood and fire tending, washing dishes or clothes, and hauling water or preparing produce and meals were assigned to older children or to related children. The child-minders' responsibilities increased as their charges grew less dependent on mother's milk. Because of this support network, infant-feeding requirements imposed few restrictions on the mothers' activities in the fields or participation in important activities, such as visits to other villages and trading, work parties, ceremonial exchanges, and feasting.

Several women stated that because children were said to dislike the unpleasant taste of the breastmilk when their mothers became pregnant again, children some-times weaned themselves. Traditionally, solid food was withheld until the baby was walking. According to most informants, a child's limbs had to be strong (evidenced by unaided walking or by vigorous crawling) before the child was fed supplementary foods. The author reported that solid food was now given whenever the child demanded it, and once it had teeth biting of the breasts signaled the child's readiness for insects as a supplement. In Usino, because of the belief that pro-longed crying of infants induced illness or soul loss, they were breastfed frequently to prevent them from crying. Sometimes, however, a frustrated mother, inter-preting her infant's incessant cries as signs of hunger, would rebel at such persistent demands and wander out of earshot. In these cases, the husband or older female relatives would chastise her, or even physically punish her, for such irresponsible behavior.

The most serious inhibitor of a woman's activities was not that she was breastfeeding a baby, but rather her perception of her own health, or that of other family members. The author observed that a mother who was preoccupied with her own physical distress demonstrated little interest in the well-being of her children. In addition, because a woman's husband and children contributed to the household economy, any illness among them resulted in an increase in the woman's workload while she cared for the ill family members, and her agricultural and other economic activities were curtailed, the more so if she had to seek treatment for them at the Usino Patrol Post or at the Health Center.

The practice of adoption of young children might influence feeding after sevrage, but it rarely occurred before that event. According to the author, one over-burdened couple who consistently broke postpartum sex taboos promised their newborn to another couple who had one son and were experiencing difficulty in conceiving another child. The adoptive mother, who had not lactated in four years, assured the author that if she applied hot water to her breasts and a ritual special-ist administered the appropriate spell, she would soon be able to nurse the child herself. The author stated that she recorded two other similar cases of induced lactation.

Case study 14. Solomon Islands (inland and coastal communities in Malaita) [61]

Background

Malaita, a volcanic island 100 miles long and 25 miles wide in the Solomon Islands, is home to approximately 10 ethnolinguistic groups. Two major Kwaio-speaking groups, pagans and *sukurus*, live in the East Kwaio Dis-trict of Malaita. The pagans have a strong emotional commitment to the ways of their ancestors and practice their traditional religion. *Sukuru* is a term derived from the English word school, related to the Christian mis-sionary schools. The *sukurus* follow a Christian belief system but not the lifestyle of conventional Western Christianity. The research was carried out from 1979 to 1983 and was conducted in-residence. Traditional pagans most often live inland in isolated hamlets in patrilocal residences, averaging nine people. They subsist on swidden (slashing and burning) agriculture, some pig-raising, foraging, fishing, and hunting. Sweet potato replaced taro as the major food crop after a taro blight in the 1950s. Pagan women may not eat certain foods, including bananas, pigs that have been hunted, stolen, or ritually slaughtered, certain fish species, opossums, fruit bats, eels, and about half of the birds that are locally consumed. Edible insects are commonly consumed by women because they are reported to be as good as or better than fish as a source of protein.

Shell money was more valuable than cash in the local economy. Medical care was infrequent in the inland hamlets due to inaccessibility, although a part-time nurse and occasional medical tours made visits. The Christian hospital on the coast did not attract many pagan Kwaio because of religious differences and the difficulty of land travel. The pagans, however, desired Western medicine. The *sukuru* villages are largely on the coast, and people live more densely than in the rural areas inland. These villages are much larger than the pagan compounds, ranging from 10 to 180 people concentrated around a church. The *sukuru* had greater access to cash and foreign goods, education, and health care. The economy focused on copra and cattle-rais-ing. There were problems with drinking water and the position of latrines. The study documents traditional

infant feeding practices in their social and cultural context, and the changes that have occurred among more acculturated members of East Kwaio (largely the *sukurus*).

Data on infant feeding and child care were collected largely by participant observation and by 25 semistructured interviews with 12 pagan and 13 *sukuru* Kwaio mothers. Of those interviewed, 17 (64%) lived inland and 8 lived on the coast. Research was conducted in the Kwaio language. All verbal reports were cross-checked and verified by observation when possible.

Food type and age of introduction (what)

Both pagans and *sukurus* breastfed and used bottles for supplemental feeding, but the practices and timing differed. All mothers fed premasticated taro and water if no lactating woman was available to wet-nurse. Breastmilk substitutes offered included powdered or tinned milk and "soup-soup" (sweet potato cooked in coconut milk). Water, limeade, Milo drink (rarely), and powdered milk (occasionally) were given by bottle. The use of infant formula was not reported.

Pagan. Infants received most of the colostrum produced by the mother. One-third of the women gave the first solid foods at one to two weeks postpartum, and the other third between three weeks and two months. Sweet potatoes or taro were the first solids introduced. From 5 to 11 months of age, water, betel nut, fish, and pork were fed. From 12 to 24 months of age, the children were fed a portion of taro or pork, and the dietary staple was taro and sweet potato. Greens and high-protein foods were not given until the child reached the age of four years. Wet-nursing was not uncommon.

Sukuru. Information was provided only where it differed from traditional pagan practice. Some women discarded their colostrum, but the traditional practice was to give colostrum to newborns. One-quarter of the mothers gave premasticated food to the infants before they could crawl. Most introduced solids between six and nine months. Soup-soup is made by boiling sweet potato in coconut milk and is the preferred introductory food. Some mothers allowed wet-nursing.

Food preparation and feeding style (how)

Pagan. From birth to four months, before breastfeeding breastmilk was expressed by hand. The first solids were premasticated and fed mouth-to-mouth in small, well-chewed amounts. The mother then gave the breast to make the infant swallow the premasticated solids. From 5 to 11 months, food was premasticated less thoroughly and put into the infant's hand to eat or fed mouth-to-mouth. Water was fed from a bamboo container.

Sukuru. Some women weaned their children by wearing tight clothing that prevented the child from accessing the breast. Some women sent the child away for four to five days, and other women rubbed chili or chloroquine on the breast to wean. One-quarter said that they introduced premasticated food mouth-to-mouth before the child could crawl. Solids were commonly introduced in three ways: food was premasticated into a spoon or the child's hand, boiled and mashed foods were fed using a spoon or the child's hand, or soft food was given to the child to hold and eat. Soup-soup was made by boiling sweet potato in coconut milk and was sometimes prepared only for the child. Some women who disparaged early feeding fed other mothers' infants mouth-to-mouth with premasticated food when the infants were hungry and their mothers were away. Some women wet-nursed, usually for their sisters or sisters-in-law. All mothers who had concerns about insufficient breastmilk performed certain cultural rituals to help the breastmilk return and resumed breastfeeding. They did not prevent their infants from suckling during this time. Bottles were used to feed breastmilk as well. Those who fed children with bottles, cups, or spoons washed these items without soap in cold water, as with all other household dishes. Sweet potato was boiled or mashed. Some prepared the food using pots, dishes, and other utensils acquired through a cash transaction.

Caregivers (who)

Pagan. The mothers breastfed and fed solids to their infants. The infant was sometimes left in the care of a nonlactating woman who also fed premasticated solids. All occupants of the parents' hamlet were collectively responsible for child care. Other adults and adolescents made decisions on behalf of the child. Children were never left alone. Older women, particularly grandmothers, were the preferred caregivers. Unmarried or widowed sisters of the child's father who had no children of their own often informally "adopted" the child and performed many of the child-care duties. Childless couples in the father's extended family might behave similarly. Five-year-old girls supervised by adults cared for younger siblings. Infants and toddlers were not entrusted to unsupervised children. If a family had no daughters, a male child took over these duties (but not the oldest male child). Fathers and grandfathers also helped in child care. Men tended to care for male infants and toddlers of either sex and supervised older children who were providing care. Sisters of the child's mother or father or the mother's sisters-in-law sometimes wet-nursed the child. Occasionally other female relatives helped wet-nurse children. These relatives also fed solids to the children. Unrelated women never wet-nursed for each other. Wet-nurses with infants of the same age as the biological mother's child were preferred.

Sukuru. Elderly male relatives were more likely to help with child care in *sukuru* than in pagan communities. Adults usually supervised groups of children, since the people lived closer together in these villages.

Women who were not the child's biological mother helped feed. Elderly caregivers were also common. Only sisters of the parents or the father's brother's wives exchanged wet-nursing services.

Food frequency and schedules (when)

Pagan. Mothers nursed newborns on demand. They breastfed two- to four-month-old infants on demand but also planned a good morning feed, emptying both breasts, and they frequently also breastfed at night.

Sukuru. No difference was noted from pagan practices.

Feeding environment (where)

Pagan. For two weeks postpartum, the mother lived in a special hut with the infant and was accompanied by a young female helper. The woman showed the child to the community after 14 days, then moved to another hut (*bisi* or menstruation hut) for a minimum of 40 days. Women also lived apart from the community in the *bisi* during menstruation. Boys lived and ate with their mothers in the female areas of the hamlet until they had eaten with men or had eaten sacrificial pork.

Sukuru. No other information was offered about *sukuru* feeding environments.

Sociocultural determinants (why)

Women believed that the early introduction of solid foods was essential to a child's growth. They fed solids to their infants more often when they left to perform various tasks, and the more the child ate at one time, the more comfortable they felt leaving the child in the care of others. However, women were quite concerned about the health of their children and, having been told (often by other helpers) that premastication and mouth-to-mouth feeding were unhealthy, they expressed concern about how to feed their children while at work.

The length of time a mother spent away from the child increased as the child got older. Whether they lived inland or on the coast, pagan women had a heavy workload. At the same time, even quite progressive families did not view mothers exclusively as homemakers, because their work activities were seen as essential to the subsistence economy and also a source of prestige. In traditional Kwaio society, a woman's prestige came from her dual role as provider and mother. Thus, there was an incentive for her to return to work as soon as she felt up to it following childbirth. In the view of the ethnographer, prestige was not gained by imitation of Western lifestyles or the use of modern technology, but rather by the ability to blend new innovations with the ancient worldview.

Sukuru coastal dwellers have been influenced by missionaries, particularly the Adventists, who emphasized Western health care, nutrition, and hygiene in their religious teachings. The Adventists forbade their followers to eat pork, shellfish, and insects. *Kwaio* beliefs are different from Western medical beliefs, and disease is not associated with food but is believed to have supernatural causes.

Case study 15. Trobriand Islands (rural island village) [62]

Background

Field observations and interviews on infant and child nutrition occurred over the course of three separate visits to Kaduwaga Village on Kaileuna Island, Trobriand Islands. Data were collected over a 14-month stay in 1971–72 and on subsequent two-month trips in 1980 and 1981. Infants and children were studied during mealtimes and other feeding episodes. Local adult views were sought on the subject of the children's diet and health. Kaduwaga Village has a stable population of around 300. It lies by the ocean where a coral reef extends outward for a third of a mile. Marine foods from shallow or deep waters are eaten daily. Cultivation gardens provide an extensive variety of vegetables, yams, and taro. Coconut milk is included in almost every prepared dish. An uncontaminated source of groundwater provides the village with an ample supply of fresh water.

Food type and age of introduction (what)

Infants were fed soup a few weeks after birth. Soon after, the mothers offered solid foods, usually starches. Infants were given fish, yams, taro, and vegetables.

Food preparation and feeding style (how)

Soup was provided in small amounts. The mothers premasticated and/or mashed solids before feeding them to the infants. Parents urged their children to eat solids, particularly yams and taro. Infants were allowed to eat what and when they wanted, but were urged to eat starchy foods daily. Foods were carefully washed in fresh water before cooking. After cooking, the food was covered to avoid contamination. Food over one day old was recooked every day thereafter "to retard spoilage and ensure wholesomeness."

Caregivers (who)

The parents prepared and served food to their infants until the child was weaned. When weaning began, the child was left increasingly in the company of other adults, who provided food to the child.

Food frequency and schedules (when)

The infants were offered solid foods three times daily but were allowed snacks throughout the day. Parents permitted infants and young children to eat when they wanted.

Feeding environment (where)

Traditionally, but less so in recent years, mothers and their newborns were secluded for six months postpartum, or until the mother's skin paled to the same complexion as the baby's. The seclusion house was dark and smoky, and a fire was lit within to keep the temperature of the mother's milk warm. The mother sat with and fed her infant on a platform over the hearth. Men were banned from the house. No information was available on the feeding environment for children not secluded or those over the age of six months.

Sociocultural determinants (why)

Infants, like other members of Kaduwaga society, were believed to grow because "adults invest labor in creating and growing them." Parents closely watched for signs of health impairment in their children and endeavored to give them first-rate care. Parents tended to be excessively anxious about accidents, because they thought that infants lacked mental responsibility and strong bodies. The locals believed that poor health came from improper diet, sorcery, and injury. Foods were divided into two categories: *kanua* and *kawenu*. *Kanua* can be translated to mean "human-body-substance-building food, or men's food," and consists of taro and yams, providing the substance for growing distinctively human bodies and sustaining life. It was termed men's food because men were believed "to possess the environment-controlling magic that creates the conditions necessary for growth." Humans were categorized by their degree of bodily solidity, "suitable for residence on the solid ground." *Kawenu*, conversely, was defined as "human-body-substance-individuating food, or women's food," which could not keep humans alive but could alter the densities of human bodies. *Kawenu*, consisting of wild or exotic vegetable food, was women's food because women gathered and planted it.

Infants were thought to possess a small amount of body substance and to be relatively unsolid. Mothers focused much attention on increasing the size and solidity of their infants' bodies. *Kanua* was thought to build bodies and thus became the priority food for infants. Breastmilk was believed to be a liquid form of *kanua*, formed by *kanua* consumed by the mother. Powdered milk was unpopular and was considered Western *kawenu* that did not form solid bodies.

Geographic area: North America

Case study 16. Baltimore, Maryland, USA (urban, African-American) [63]

Background

The data in this report were obtained as part of a formative research effort undertaken in preparation for a larger study evaluating the effectiveness of a parenting intervention among adolescent mothers in Baltimore, Maryland, USA. Nineteen adolescent mothers were recruited from Baltimore WIC (Supplemental Services to Women, Infants, and Children) programs. To be eligible to participate in the study, the mother had to be between 13 and 20 years of age, African-American, a first-time mother, living with her own mother, and low-income (defined as being eligible for WIC services).

Qualitative research methods were used to obtain in-depth case studies of eligible households, and data were collected in a series of semistructured interviews. Ethnographic field guides were prepared in advance and used during the interviews. The questions in the guides reflected current knowledge about infant feeding practices in this population obtained from the literature, as well as concepts arising from the conceptual ecological model used by the authors. Because the guides were occasionally revised so that new issues identified in early interviews could be followed up in later interviews, the methodology followed an iterative and flexible approach that allowed new questions to be asked throughout the course of data collection. All but two interviews were conducted in the informant's home. Each interview was tape-recorded and transcribed, and then stored in a computerized database.

The authors hypothesized that the use of qualitative research methods, coupled with an ecological, multigenerational focus, would provide a rich description of the context within which infant feeding decisions are made.

Food type and age of introduction (what)

Twelve of the 19 households voluntarily reported that they added cereal to the baby's formula, usually at about three weeks of age. Other foods, such as mashed potatoes and applesauce, were frequently fed within the first one to two months of the baby's life.

Food preparation and feeding style (how)

Cereal mixed with formula was fed in a bottle to 49% of the infants, whereas cereal mixed with applesauce was fed with a spoon to 34% and cereal alone was fed with a spoon to 22% of the infants.

Several mothers and grandmothers reported, without prompting, that they prechewed the baby's food. For example, when asked what her baby was fed the previous day, the mother of a seven-month-old baby was reported to have said that she gave the baby "some Kentucky Fried Chicken food…. Yeah, she ate some of that, but I kind of like chewed it up." This same mother later reported "She eats pancakes. I fed her that yesterday. I chop it up or chew it up myself because I'm afraid she might choke."

In another case, both the grandmother and the mother of an eight-month-old baby reported chewing

up the baby's food for him "because he don't have any teeth yet."

Caregiver (who)

Mothers and grandmothers fed the infants. Who fed the infants was not discussed further.

Food frequency and schedules (when)

The authors reported that one grandmother of a 10-month old baby, who had been eating "regular food… since he was born," said, "If that's what I want, then he going to eat what I eat…morning, lunch and dinner. When he wake up in the morning, I'm usually eating sausage and eggs, I put him some on the side…. And like lunchtime, it might be a sandwich or something. I just give him the meat and stuff."

The mother of a two-month old baby was reported to have said, "He eat a lot…he got to eat like every three hours and I can eat whenever I get ready."

Feeding environment (where)

The feeding environment was not discussed

Sociocultural determinants (why)

Grandmothers were heavily involved in helping the adolescent mothers with child care, often so that the mothers could attend school. Of the 19 adolescent mothers, 15 were either enrolled in school or were planning to return soon, 3 had graduated from high school, and 1 had dropped out. In 9 out of 15 of the households, the maternal grandmothers juggled their schedules and/or worked evenings to be available to provide child care during the time their daughters were in school. One grandmother, who held a full-time job, paid for her grandchild's day-care expenses so that her daughter could continue school. In the remaining households, other family members, such as aunts or great-grandmothers, provided child care, or day care was obtained at the school or funded by social services. Maternal grandmothers were also frequently reported as a source of babysitting, when the mothers wanted to go out with friends after school or in the evenings, or to do errands.

The child characteristics that most influenced feeding decisions were body size, crying and sleeping patterns, and appetite. The mothers in several households reported that their baby was smaller than they thought he should be and that they introduced nonmilk foods so that the child would grow better. One baby started receiving applesauce at three weeks of age because "he was just skinny, real skinny." One grandmother in the study reported that her grandchild had been eating "regular food…since he was born" and explained that she made the decision to feed him regular food "cause he was too little." The child's small size or lack of expected growth was also reported by several other

mothers and grandmothers. The addition of cereal or other nonmilk foods to the baby's diet was also a strategy used to manage other parenting concerns, prompted by the baby's behavior. For example, cereal and other solids were frequently introduced to the infant's diet in an effort to stop the baby from crying or to lengthen the amount of time the baby slept. One mother was reported to have said that she introduced these foods "so he won't be crying, whining, or stuff, you know. People say, 'Oh give him that baby food.' Baby food ain't no good." The caregivers in more than half of the households who admitted to adding cereal to the bottle in the first weeks and months of an infant's life explained that the baby was crying too much or not sleeping through the night.

The caregiver's interpretation of another child characteristic, the baby's appetite (often described as "greedy"), had a particularly important influence on feeding practices. For example, many respondents expressed their belief in the need to mix cereal with the formula because of the baby's appetite. In 10 of the 19 households in this study, the word "greedy" was spontaneously used to describe a hearty appetite, and most respondents seemed to prefer a "greedy" to a "picky" eater. One mother said, "He's greedy. It's good because he's real greedy. Because I give him like six ounces and he still be wanting some more, so I just give him some more. He's real greedy." The child's appetite and desire for "real" food was often given as a reason for the early introduction of other nonmilk foods, such as jarred baby food, mashed potatoes, or macaroni. Fifty percent of the mothers based their decision to give complementary foods on infant cues, such as "He wasn't getting full" and "She didn't seem satisfied." A third of the mothers reported their own beliefs, such as "I wanted her to taste it" and "I felt like it was time," to explain their decision to introduce complementary foods.

Health professionals' advice to delay the introduction of solid foods often contradicted the grandmother's beliefs and theories about infant feeding. Frequently, the adolescent mother would state that she was aware of the health professional's recommendations, but would nevertheless end up going along with the grandmother's desire to start cereal and other solid foods earlier, either because they wanted to avoid a confrontation or "because she know better than me." In one household, the mother reported that she was following the doctor's recommendations and would not introduce cereal until the baby was "probably about three months," and would start jarred baby food at about six months because "babies can't handle food that we eat. It won't settle in their stomach right." However, in this same household the grandmother reported she was secretly adding cereal to the baby's formula without the mother's knowledge.

Although grandmothers had extensive physical access

to the babies and ample opportunity to implement their preferred feeding practices, the grandmother's influence on infant feeding often occurred as a result of the dependent nature of the mother's relationship with the grandmother. Nearly all adolescent mothers stated that they would ask their own mother (that is, the baby's maternal grandmother) if they needed advice about infant feeding. This reliance on grandmothers was understandable, given each mother's developmental stage, her status as a first-time parent, and her economic and emotional dependence on the grandmother.

The grandmother's influence on infant feeding decisions occurred through one of three mechanisms: the adolescent mother actively sought out the grandmother's advice, the maternal grandmother took the initiative on infant feeding decisions and the adolescent acquiesced, or the maternal grandmother implemented her preferred feeding practices without the mother's knowledge. The most common was the first mechanism, in which the adolescent mother actively sought out, then quickly accepted and implemented, the grandmother's advice on feeding. For example, one mother was reported to have said, "Sometimes I don't know what type of food to feed him and she'll let me know. Like with the potatoes. I ask her, 'How you fix the potatoes? You know the quick way to fix it.' She be like, 'Just put it in the microwave for about three or four minutes. And it'll be done.'" Another mother, when asked what made her decide to give the baby Enfamil, responded, "My mother…I know she knows what's best."

An illustration of the second mechanism is the case of the young mother who, when asked when she started feeding her baby food, replied, "Well, not me. My mother. Really when she started reaching out for food I think was at four months." The third mechanism occurred when the grandmother knew the mother felt strongly about the baby's not eating food other than milk. In this case (the only clear example that the authors uncovered in the analysis), the grandmother bypassed the mother and implemented her own preferred feeding practice without the mother's knowledge. The grandmother told the interviewer how she sneaked cereal into the baby's bottle: "I told Sarina I was gonna put him on cereal now, but she's scared. Maybe I'll sneak it in there, you know. (Laughter) When I make the bottles, I make like two bottles with cereal in it. She says, 'No, he's too fat, he don't need anything in it. I'm scared he's gonna be overweight.' I started giving it to him when he was maybe about five weeks." When asked why she did it, the grandmother explained, "Because she's not ready to give it to him and I want him to have it…. And when I gave him cereal one night, she said 'Ma, he slept all night.' I said, 'Oh, he did?' (Laughter)."

Case study 17. Lexington, Kentucky, USA (low-income urban community) [64]

Background

A total of 41 mothers enrolled in the local WIC program were interviewed in Lexington, Kentucky, USA; 21 were black and 20 were white. The mothers ranged in age from 18 to 34 years, and on average had less than a high school education. Half of the white mothers and two-thirds of the black mothers were multiparous. Most of the white mothers and half of the black mothers neither worked nor attended school. Black mothers were more likely than white mothers to live with the families into which they were born, whereas white women tended to live with a male partner in a nuclear unit. Seventy-five percent of the women in both groups interacted with male partners daily. Women were selected for the study on the basis of their participation in WIC and their stage of motherhood (in the last trimester of pregnancy, with an infant aged one or two months, or with an infant aged three or four months). To be eligible for WIC, the mothers had to have an income that was lower than 185% of the poverty line. The majority of the women were interviewed at home three times at one-month intervals. This strategy was used to cover the infant feeding window from the perinatal period to seven months postpartum. The interviews focused on the mothers' decisions regarding the introduction of solids, breastfeeding, and bottle-feeding, and included open-ended questions. The results showed few differences related to ethnicity and more homogeneity than expected, perhaps because of the similar socioeconomic conditions of all of the women.

Food type and age of introduction (what)

Although breastfeeding was considered the normative pattern, most mothers bottle-fed. The formula used was often the same brand as that given to the mother by the hospital at delivery, and tended to be iron-fortified and cow's milk–based. Some pediatricians provided soy or non-iron-fortified formulas for babies who could not tolerate the original formula. The mothers agreed that solids should be introduced at 16 weeks, but almost half of the mothers in both groups gave solids before two months. The mothers introduced cereal before pureed fruits, vegetables, and meats. Nonpureed table foods were introduced last. Meats were not typically fed until four to six months or later.

Food preparation and feeding style (how)

Many mothers added cereal to bottles. There was no difference in the proportion of black and white mothers who added cereal to bottles.

Caregivers (who)

Mothers received help in child care from paternal

grandmothers, older sisters, and sisters-in-law in particular. Fathers, brothers, and male members of the extended family also helped with child-care tasks.

Food frequency and schedules (when)

Food frequency and schedules were not discussed.

Feeding environment (where)

The mothers propped up the bottles for infants, using a pillow or other support that enabled the infants to feed themselves unassisted. White mothers were more likely than black mothers to prop up the bottles.

Sociocultural determinants (why)

Most whites cited lifestyle restrictions, such as freedom to leave the house, as reasons for not initiating breastfeeding, whereas African-Americans cited inconvenience as a reason. More white mothers than black mothers sometimes propped up a bottle on a pillow or other support while they were busy with household or family chores. The mothers felt that the infants would be able to feed themselves and develop their grasping skill.

Solids, especially cereal mixed with formula, were introduced early by some black mothers and some white mothers to help their infants sleep through the night. Those who mixed formula and cereal also felt that this practice would reduce the amount of formula the infant consumed, allowing the mother to feed less frequently and to get a good night's rest. Although breastfeeding was viewed as the best way to feed an infant by three-quarters of both black and white respondents, use of the bottle emerged as the dominant feeding method. Because it was believed that infants who can eat a variety of foods are more advanced than those who cannot, some mothers introduced solids early to demonstrate an infant's developmental progress. For formula-fed infants, signs of illness, such as vomiting and diarrhea, were perceived as reasons to switch from a formula to cow's milk.

Many black respondents mentioned pain and physical discomfort as a reason not to initiate breastfeeding.

Members of both ethnic groups cited WIC staff, pediatricians, and maternal grandmothers as the key advisors on the introduction of solid foods. Current medical recommendations influenced most black and white mothers' infant feeding decisions, and the infant formula provided by the hospital where the mother delivered tended to be the brand the mother initially used. However, both blacks and whites noted that messages from physicians were mixed: some favored breastfeeding while others were neutral. Physicians and maternal grandmothers were the most influential advisors on infant feeding. Others who gave advice included maternity nurses and WIC nutritionists, but the mothers seldom cited these as very influential sources. Respondents who did not live close to family cited health professionals alone, or both health professionals and network members, as their key sources of advice on infant feeding. Embarrassment and modesty led some not to initiate breastfeeding.

WIC and most pediatricians advised mothers against propping up the bottle and adding cereal to the formula. For one-third of black and white women in this study, boyfriends or husbands tried to influence their infant feeding decisions. The authors reported that "among whites, male partners are most likely to favor breastfeeding, while the majority of maternal grandmothers disapprove of nursing. Advice from friends is mixed. Among black respondents, maternal grandmothers again mostly disapprove of breastfeeding. Friends, on the other hand, are likely to encourage nursing." White mothers reported that their male partners tended to favor the early introduction of solids. Social network members, particularly maternal grandmothers and male partners, were often concerned that breastmilk or formula was not meeting the baby's dietary requirements. They tended to think that increasing the intake of breastmilk or formula could not address the child's apparent hunger cues. Mothers viewed people who expressed strong opinions about infant feeding as good alternative caregivers; however, because they considered this information unreliable, such advice was often ignored.

Case study 18. Philadelphia, Pennsylvania, USA (urban, middle and upper income) [65]

Background

Research was conducted as part of a larger study examining the biocultural determinants of infant feeding practices and physical growth in Philadelphia, Pennsylvania, USA. Women were recruited for longitudinal and cross-sectional studies. The longitudinal study lasted six months and included 14 first-time mothers of middle and upper-middle income status who were recruited through childbirth education classes and personal networks. This group was screened to ensure highly motivated, interested, and dependable participants. Most were well educated, with an average of 16.1 years of education, and had equal access to pediatricians in private or group practice. The women were interviewed an average of 15 or 16 times, first during the last trimester of pregnancy and then at regular intervals for the first year postpartum.

The cross-sectional studies were undertaken with two groups of women, both with children between 2 and 12 months old. One group was of low income and low educational status ($N = 54$), and the other was similar to those in the longitudinal study ($N = 23$). The women were interviewed for 30 minutes while waiting to see a physician. The cross-sectional sample represented the great heterogeneity of the population of the city. The goal of the cross-sectional research was

to describe current infant feeding practices and their history since birth. The researchers sought to learn why mothers chose a particular method of infant feeding, and who were their sources of advice. Data are reported for all mothers or for a particular group.

Food type and age of introduction (what)

All infants were breastfed upon discharge from the hospital. Breastfeeding was then continued from four days to 12 months (the maximum age of the children in the study). Once formula began to be introduced regularly with breastfeeding, the mothers initiated weaning. The infants tended not to be fed family foods or table foods until they reached six months of age. Mothers reported feeding children low-fat milk and foods without excess sugar or starch. Cereal preceded other foods and was often mixed with fruit. Fruit juice was also deemed acceptable. Commercially prepared baby foods were also popular. Some mothers used trial and error to discern which foods the child could tolerate. For example, one mother said, "I gave Steven some yogurt, but it gave him diarrhea. I guess his system isn't ready to handle it now, but I'll try again when he's a little older."

Food preparation and feeding style (how)

Some women elected to breastfeed, whereas others chose to bottle-feed from birth. Mothers who wished to continue breastfeeding upon returning to work were frustrated by how much time hand-expressing of breastmilk consumed. Formula often became the choice of convenience, although not the ideal. Some mothers idealized home-prepared foods, but time constraints limited these mothers' ability to provide this diet daily to their infants. Commercially available baby foods in jars were commonly served to children. The mothers had a clear idea about the characteristics of foods appropriate for infants: strained, mushy, bland, nutritious, and without additives (usually referring to sugar, salt, preservatives, and colorings).

Caregivers (who)

Mothers are described as infant caregivers. This subject was not explored in depth. Social network members were studied insofar as they were offering advice to new mothers. Their role as alternative caregivers was not discussed.

Food frequency and schedules (when)

Food frequency and schedules were not discussed.

Feeding environment (where)

The feeding environment was not discussed.

Sociocultural determinants (why)

Mothers breastfed because of the cost savings and convenience in comparison with the alternatives. However, some women considered breastfeeding to be inconvenient and to require much time and energy. Others felt that one disadvantage of breastfeeding was being tied to the home and the infant, as well as lifestyle restrictions. Breastfeeding mothers considered the disadvantages of breastfeeding more an annoyance rather than reasons to bottle-feed, but bottle-feeding mothers often cited these issues as reasons for changing the feeding method. When a mother needed to return to work outside the home, hand-expressing of breastmilk became too time-consuming, and the infant was given formula instead. Jarred baby foods were considered convenient and practical.

Breastfeeding was thought to be beneficial to infants because it prevented disease and allergies and provided good nutrition. A disadvantage of breastfeeding, as perceived by the mothers, was that fathers or others could not participate in the feeding experience. Reading materials that highlight the biological aspects of breastfeeding were a primary source of information about infant feeding for the more educated mothers. The mothers believed it was important to prepare mashed or strained foods for infants who lacked teeth for ease of consumption. Variety in the infant diet was valued, as was establishing good eating habits early in life. The mothers endeavored to prepare or provide foods low in salt out of concern for predisposing the infant to hypertension. Fatness in babies was not valued, because it was believed that fat babies would become fat adults; leanness was considered the current prevalent cultural value in the United States. Many mothers based these beliefs on magazine articles or television talk shows. They believed that one could avoid overfeeding and prevent fatness by learning an infant's hunger cues. Other strategies to prevent fatness included avoiding early introduction and unnecessary feeding of solids, and withholding whole milk and foods with excess sugar or starch.

Mothers who took medication for illness were concerned about its effects on the breastfeeding infant. Concerns arose about whether the mother's milk was sufficient for the child, or whether the child needed supplements or vitamins. Physicians were often consulted about maternal health concerns related to breastfeeding. The less educated mothers reported personal networks of friends and relatives as sources of information on infant feeding practices. Younger primiparas, especially those who lived with their parents, sought advice from their mothers. Mothers who attended prenatal childbirth classes considered these very helpful for advice and support with regard to infant feeding. Mothers who saw a private pediatrician viewed the doctor's instructions about complementary foods as "prescriptions." The more directives from the pediatrician, the more mothers complied with the advice. Mothers who visited public clinics relied less on the pediatrician's recommendations and reported making their own decisions about complementary feeding.

References

1. Brown KB, Dewey K, Allen LH. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: World Health Organization, 1998.

2. Beaton GH, Ghassemi H. Supplementary feeding programs for young children in developing countries. Am J Clin Nutr 1983;35:863–916.

3. Caulfield LE, Huffman SL, Piwoz EG. Interventions to improve the complementary food intakes of 6- to 12-month-old infants in developing countries: impact on growth, prevalence of malnutrition, and potential contribution to child survival. Food Nutr Bull 1999;20:183–200.

4. Munoz de Chavez M, Arroyo P, Perez Gil S, Hernandez M, Quiroz S, Rodriquez M, de Hermelo M, Chavez A. The epidemiology of good nutrition in a population with a high prevalence of malnutrition. Ecol Food Nutr 1974;3:223–30.

5. Zeitlin M, Houser R, Johnson FC. Active maternal feeding and nutritional status of 8–20-month-old Mexican children. Kansas City, Mo, USA: Society for Research in Child Development, 1989.

6. Zeitlin MF, Ghassemi H, Mansour M. Positive deviance in child nutrition. Tokyo: United Nations University, 1990.

7. Zeitlin MF. Child care and nutrition: the findings from positive deviance research. Nutrition Monograph Series No. 27. Ithaca, NY, USA: Cornell International Nutrition Program, 1996.

8. Engle P. Caretaker competence. Abstracts of the 86th Annual Meeting of the American Anthropological Association. Washington, DC: American Anthropological Association, 1987.

9. Pelto GH. Maternal care-giving and nutrition. In: Young KW, Cha LY, Yull LK, Soon JJ, He KS. Proceedings of the 14th International Congress of Nutrition. Seoul, Korea: Fourteenth International Congress of Nutrition Organizing Committee, 1989:729–33.

10. Martines JC. The interrelationships between feeding mode, malnutrition and diarrhoeal morbidity in early infancy among the urban poor in southern Brazil. London: Human Nutrition Department, London School of Hygiene and Tropical Medicine, University of London, 1988.

11. UNICEF. Strategy for improved nutrition of children and women in developing countries. New York: UNICEF, 1990.

12. Pelletier D. Toward a common understanding of malnutrition: assessing the contributions of the UNICEF framework. New York: UNICEF, in press.

13. Food and Agriculture Organization of the United Nations and World Health Organization. Major issues for nutrition strategies. International Conference on Nutrition. ICN/92/INF/7. Rome and Geneva: FAO and WHO, 1992.

14. Engle PL. Childcare and nutrition. Theme Paper for the International Conference on Nutrition. New York: UNICEF, 1992.

15. Special issue on care and nutrition of the young child. Food Nutr Bull 1995;16:281–412.

16. Engle PL, Menon P, Haddad L. Care and nutrition: concepts and measurement. Food Consumption and Nutrition Division Discussion Paper No. 18. Washington, DC: International Food Policy Research Institute, 1996.

17. Arimond M, Ruel MT. Assessing care: progress towards the measurement of selected childcare and feeding practices, and implications for programs. FCND Discussion Paper No. 119. Washington, DC: Food Consumption and Nutrition Division, International Food Policy Research Institute, 2001.

18. Bentley ME, Pelto GH, Straus WL, Schumann DA, Adegbola C, de la Pena E, Oni GA, Brown KH, Sandra LH. Rapid ethnographic assessment: applications in a diarrhea management program. Soc Sci Med 1988;27:106–16.

19. Bentley ME, Dickin KL, Mebrahtu S, Kayode B, Oni GA, Versoza CC, Brown KH, Idowu JR. Development of a nutritionally adequate and culturally appropriate weaning food in Kwara State, Nigeria: an interdisciplinary approach. Soc Sci Med 1991;33:1103–11.

20. Bentley ME, Stallings RY, Fukumoto M, Elder JA. Maternal feeding behavior and child acceptance of food during diarrhea, convalescence, and health in the Central Sierra of Peru. Am J Public Health 1991;81:43–7.

21. Engle P, Zeitlin M. Active feeding behavior compensates for low interest in food among young Nicaraguan children. J Nutr 1998;126:1808–16.

22. Bentley ME. Caretaker style of infant feeding as a determinant of dietary intake: the need for promotion of "interactive" feeding. FASEB J 1999;13:A211.

23. Birch LL, Fisher JA. Appetite and eating behavior in children. Pediatr Clin North Am 1995;42:931–53.

24. Dettwyler KA. Styles of infant feeding: parental/caretaker control of food consumption in young children. Am Anthropol 1989;91:696–703.

25. Gittelsohn J, Shankar AV, West KP, Faruque F, Gynwali T, Pradhan DE. Child feeding and care behaviors are associated with xerophthalmia in rural Nepalese households. Soc Sci Med 1998;36:925–35.

26. Harkness S, Super CM. The developmental niche: a theoretical framework for analyzing the household production of health. Soc Sci Med 1994;38:217–26.

27. Harkness S, Super CM, eds. Parent's cultural belief systems: their origins, expressions, and consequences. New York: Guilford Press, 1996.

28. Cleland JG, Van Ginneken JK. Maternal education and child survival in developing countries: the search for pathways of influence. Soc Sci Med 1988;27:1367–8.

29. Ruel MT, Habicht J-P, Pinstrup-Andersen P, Grohn Y. The mediating effect of maternal nutrition knowledge on the association between maternal schooling and child nutritional status in Lesotho. Am J Epidemiol 1992;35:904–14.

30. Reed BA, Habicht J-P, Niameogo C. The effects of maternal education on child nutritional status depend on socio-environmental conditions. Int J Epidemiol 1996;25:585–92.

31. Menon P, Habicht J-P, Zeitlin M. Maternal caring behaviors mediate the influence of maternal schooling on child nutrition in rural Bangladesh. FASEB J 1999;13:536.

32. Pelto GH. Improving complementary feeding practices and responsive parenting as a primary component of

interventions to prevent malnutrition in infancy and early childhood. Pediatrics 2000;106:1300–1.

33. Leslie J. Women's work and child nutrition in the Third World. In: Leslie J, Paolisso M, eds. Women, work and child welfare in the Third World. Boulder, Colo, USA: Westview Press, 1988:19–58.

34. Van Esterik P. Care, caregiving, and caregivers. Food Nutr Bull 1995;16:378–88.

35. Pelto GH. Perspectives on infant feeding: decision-making and ecology. Food Nutr Bull 1981;3:16–29.

36. Allen L, Pelto GH. Research on determinants of breast-feeding duration: suggestions of biocultural studies. Med Anthropol 1985;9:97–105.

37. Van Esterik P. Beyond the breast-bottle controversy. New Brunswick, NJ, USA: Rutgers University Press, 1989.

38. Sellen DW. Comparison of infant feeding patterns reported for non-industrialized populations with current recommendations. J Nutr 2001;131:2707–15.

39. World Health Organization. IMCI Handbook. WHO/FCH/CAH/00.12. Geneva: WHO, 2000.

40. Gordon JE, Chitkara ID, Wyon JB. Weanling diarrhea. Am J Med Sci 1963;246:245–51.

41. Hibbert JM, Golden MH. What is the weanling's dilemma? J Trop Pediatr 1981;27:255–8.

42. Rowland MG. The weanling's dilemma: Are we making progress? Acta Paediatr Scand 1986;323(suppl):33–42.

43. Martines JC, Habicht JP, Ashworth A, Kirkwood BR. Weaning in southern Brazil: Is there a "weanling's dilemma"? J Nutr 1994;124:1189–98.

44. Raphael D. The tender gift. New York: Schocken Books, 1976.

45. Oni GA, Brown KH, Bentley ME, Dickin KL, Kayode B, Alade I. Infant feeding practices and prevalence of hand feeding of infants and young children in Kwara State, Nigeria. Ecol Food Nutr 1991;25:209–19.

46. Mabilia M. Beliefs and practices in infant feeding among the Wagogo of Chigongwe (Dodoma rural district), Tanzania: breastfeeding. Ecol Food Nutr 1996;35:195–207.

47. Mabilia M. Beliefs and practices in infant feeding among the Wagogo of Chigongwe (Dodoma rural district), Tanzania: weaning. Ecol Food Nutr 1996;35:209–17.

48. Dettwyler KA. Infant feeding in Mali, West Africa: variations in belief and practice. Soc Sci Med 1987;23:651–64.

49. Dettwyler KA. Breastfeeding and weaning in Mali: cultural context and hard data. Soc Sci Med 1987;24:633–44.

50. Cosminsky S, Mhykiyi M, Ewbank D. Child feeding practices in a rural area of Zimbabwe. Soc Sci Med 1993;36:937–47.

51. Wright MM, Dutra de Oliveira JE. Infant feeding in a low-income Brazilian community. Ecol Food Nutr 1988;23:1–12.

52. Izurieta LM, Larson-Brown LB. Child feeding practices in Guatemala. Ecol Food Nutr 1995;33:249–62.

53. Bentley ME, Elder J, Fukumoto M, Stallings RH, Jacoby E, Brown K. Acute childhood diarrhea and maternal time allocation in the Northern Central Sierra of Peru. Health Pol Plan 1995;10:60–70.

54. Creed Kanishiro H, Fukumoto M, Bentley ME, Jacoby E, Verzosa C, Brown KH. Use of recipe trials and anthropological techniques for the development of a home-prepared weaning food in the Central Highlands of Peru. J Nutr Educ 1991;23:30–5.

55. McClennan JD. Infant feeding practices in a poor district of Santo Domingo. Ecol Food Nutr 1994;32:167–79.

56. Bohler E, Staffan B. Premature weaning in East Bhutan: only if mother is pregnant again. J Biosoc Sci 1995;27:253–65.

57. Guldan GS, Zeitlin MF, Beiser AS, Super CM, Gershoff SN, Datta S. Maternal education and child feeding practices in rural Bangladesh. Soc Sci Med 1993;36:925–35.

58. Levine NE. Women's work and infant feeding: a case from rural Nepal. Ethnology 1988;27:231–51.

59. Acuin CCS. Emic and etic perspectives on maternal care-giving and their relationship to infant nutrition. Master's thesis, Department of Anthropology, University of Connecticut, Storrs, Conn, USA, 1992.

60. Conton L. Social, economic and ecological parameters of infant feeding in Usino, Papua New Guinea case. Ecol Food Nutr 1985;16:39–54.

61. Akin KG. Women's work and infant feeding: traditional and transitional practices on Malaita, Solomon Island. Ecol Food Nutr 1985;16:55–73.

62. Montague SP. Infant feeding and health care in Kaduwaga village, the Trobriand Islands. Ecol Food Nutr 1984;14:249–58.

63. Bentley M, Gavin L, Black MM, Teti L. Infant feeding practices of low-income, African American, adolescent mothers: an ecological, multigenerational perspective. Soc Sci Med 1999;49:1085–1100.

64. McLorg PA, Bryant CA. Influence of social network members and health care professionals on infant feeding practices of economically disadvantaged mothers. Med Anthropol 1989;10:265–78.

65. Adair L. Feeding babies: mother's decisions in an urban U.S. setting. Med Anthropol 1983;4:1–19.

Macrolevel approaches to improve the availability of complementary foods

Chessa K. Lutter

Abstract

Large numbers of infants and young children suffer from the short- and long-term health effects of poor breastfeeding and complementary feeding practices. Strategies to improve the availability of and access to low-cost fortified complementary foods can play an important corresponding role to that of behavior change in improving nutritional status of young children. However, the nutritional quality of complementary foods used in publicly funded programs is not always optimal, and such programs are costly and reach only a tiny fraction of those who could benefit. To broadly reach the target population, such foods need to be commercially available at affordable prices and promoted in a way that generates demand for their purchase. A sensible long-term policy for the promotion of low-cost fortified complementary foods calls for attention to their nutritional formulations and cost, the economics of production, and the legislative, regulatory, and competitive framework in which marketing occurs. This paper provides information on how to improve the nutritional formulations of fortified complementary foods and outlines the necessary conditions for a market approach to their production and promotion.

Key words: Fortified complementary foods, infant and young child feeding, supplementary feeding programs, commercial sector

Introduction and background

Scope of the paper

The lack of access to adequate nutrition, basic sanita-

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

tion, and health care throughout the developing world has an adverse impact on the physical and mental development of infants and young children. Poor breastfeeding and complementary feeding practices and food insecurity, together with a high prevalence of diarrhea and respiratory infections, exacerbate these inadequacies. As a result, large numbers of infants and young children suffer from short- and long-term effects on their health, which in turn impact negatively on social and economic development.

Improved infant and young child feeding behaviors do not occur in isolation but reflect the micro- and macroenvironment in which they are situated. To promote the recommended practice of exclusive breastfeeding for the first six months, changes at the individual, programmatic, and policy levels are necessary to ensure that mothers are supported to carry out this desired behavior. Thereafter, interventions to support mothers or carers and to create a favorable policy environment for carrying out the desired complementary feeding behaviors (including continued breastfeeding) are not sufficient, as the availability of and access to nutrient-dense foods becomes a necessary condition to ensure optimal nutritional status.

Strategies to improve the availability of and access to low-cost fortified complementary foods can play an important corresponding role to that of behavior change. However, the nutritional quality of complementary foods used in publicly funded programs is not always optimal. Also, such programs are costly and reach only a tiny fraction of those who could benefit from them. To reach large numbers of the target population, fortified complementary foods need to be available in the commercial market at affordable prices and to be promoted in a way that generates demand for their purchase. In this regard, the market has failed to fulfil an important function.

A sensible long-term policy for the promotion of low-cost fortified complementary foods calls for attention to their nutritional formulations and cost, the economics of production in both the public and the commercial sectors, and the legislative, regulatory, and

competitive framework in which marketing occurs. In addition, a fundamental component of such a policy is attention to consumer demand and willingness to purchase fortified complementary foods.

The objectives of this paper are twofold: to provide information on how to improve the nutritional formulations of fortified complementary foods used in publicly funded programs, and to outline the necessary conditions for a market approach to the production and promotion of low-cost, high-quality fortified complementary foods. The three main sections focus on the nutritional, economic, and policy issues that need to be considered. Recommendations for action are also provided. Because access to fortified complementary foods is mostly easy in the industrialized world, this paper focuses on the situation in developing countries. It does not address microlevel approaches to improve the availability and preparation of complementary foods at the household and community level or the critical role of feeding practices, both of which are addressed in other articles in this issue.

Background

WHO/UNICEF recommendations

Historically, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) have emphasized the use of local foods formulated in the home rather than centrally produced fortified foods for complementary feeding. The Joint WHO/UNICEF Meeting on Infant and Young Child Feeding in 1979 recommended the "promotion and support of appropriate and timely complementary feeding (weaning) practices with the use of local food resources" [1]. The recommendations went on to state: "Foods that are locally available in the home can be made suitable for weaning, and their use should be strongly emphasized in health, education, and agricultural extension programmes." The International Code of Marketing of Breast-Milk Substitutes [2] also emphasized the importance of local foods for complementary feeding and made the following statement in the preamble: "…it is important for infants to receive appropriate complementary foods…and…every effort should be made to use locally available foods…"

More recently, scientific knowledge about the energy and nutrient density needed from complementary foods has raised questions about the ability of local complementary foods to satisfy the requirements for iron, zinc, and calcium [3]. An evaluation of the nutrient density of local complementary foods, in light of the newly released US Dietary Reference Intakes (DRIs), continues to show iron, zinc, and also vitamin B_6 as problematic [4]. In addition, riboflavin and niacin are identified as problematic in some populations. The degree to which calcium, vitamin A, thiamine, folate,

and vitamin C are identified as problematic depends on whether recommendations from the United Kingdom or the United States are used.

In recognition of the potential limitations of purely home-based approaches to satisfy the requirements for these foods, the WHO/UNICEF Global Strategy for Infant and Young Child Feeding [5], ratified by the World Health Assembly in May 2002, includes the following points:

> 16. In addition, *low-cost complementary foods,* prepared with locally available ingredients using suitable small-scale production technologies in community settings, can help to meet the nutritional needs of older infants and young children. *Industrially processed complementary foods* also provide an option for some mothers who have the means to buy them and the knowledge and facilities to prepare and feed them safely. Processed-food products for infants and young children should, when sold or otherwise distributed, meet applicable standards recommended by the Codex Alimentarius Commission and also the Codex Alimentarius Code of Hygienic Practice for Foods for Infants and Children.

> 17. Food fortification and universal or targeted nutrient supplementation may also be required to ensure that older infants and young children receive adequate amounts of micronutrients.

Use of fortified complementary foods in publicly funded programs

Fortified complementary foods are widely used in publicly funded social programs throughout Latin America [6] and other regions of the world. Although there are large conceptual and practical problems in measuring the costs of such programs [7], the attempts made have shown large dollar expenditures [6]. In 1991 the World Bank estimated that US$1.6 billion was spent annually in Latin America in 104 different programs [8]. In the 1997 Peruvian National Food and Nutrition Plan, a total of US$326 million was allocated for food, a large proportion of which went to infant and young child feeding programs. A review of the US Agency for International Development (USAID) Title II Food Aid programs shows that in 1998, nearly US$50 million was spent on program support costs in Bolivia, Guatemala, Haiti, Honduras, Nicaragua, and Peru (personal communication, Rajabium S, Food and Nutrition Technical Assistance [FANTA] Project, Academy for Educational Development, Washington, DC, 1999). In Argentina, US$25 million is spent annually to provide milk to low-income women and children. Chile also has a large milk distribution program. It is likely that large expenditures from international and national budgets occur in other regions of the world, though specific information is lacking.

Not only do these programs reach large numbers of children, but they have also become part of the social

fabric and are unlikely to be eliminated. Therefore, it is incumbent on public health professionals to ensure that these programs deliver the highest-quality food at the lowest possible cost. In addition, because of the importance of nutrient-dense foods during the complementary feeding period and trends toward ever-increasing urbanization throughout the world, a renewed look at the potential marketability to middle- and low-income consumers of high-quality, low-cost fortified complementary foods is warranted.

Effectiveness in improving nutritional status

High-quality, low-cost fortified complementary foods with a good distribution system are effective in improving micronutrient status among the target population. In Peru, Alli Alimentu, a fortified complementary food that reflects the most recent scientific information on infant and young child nutrient needs, was effective in improving the energy intake and micronutrient status and significantly reduced the prevalence of anemia and of vitamin A deficiency [9]. In Chile, the fortification of milk powder with iron (10 mg/100 g as ferrous sulfate), zinc (5 mg/100 g), copper (0.05 mg/100 g), and ascorbic acid (70 mg/100 g) also resulted in significant reductions in anemia [10]. The fortification of the milk powder used in the supplementary feeding program in Argentina (12 mg of iron as ferrous sulfate, 6 mg of zinc, and 100 of ascorbic acid) has been mandated, and the evaluation is in progress (personal communication, Calvo E, Maternal and Child Health Program, Ministry of Health, Argentina, 2001).

The effect of complementary foods on linear growth is not as well established as its effect on micronutrient status [11]. However, unlike micronutrient status, linear growth reflects both nutrient intake and morbidity, which is frequent in this age group. In addition, small maternal size, itself a function of poor growth in early life, may compromise prenatal growth in a way that adversely affects the ability of children to reach their postnatal growth potential. More than one generation of improved infant and young child feeding may be necessary before the total effects on linear growth are fully measured [4].

Unfortunately, the formulations of many of the foods used in public programs do not reflect the latest scientific information on infant and young child nutrient needs, and therefore the foods may not be having the intended effect. The bioavailability of key nutrients, such as iron and zinc, is likely to be considerably less than previously believed because of the high phytate and low fat content of the older formulations. Also, because in the older formulations the fat content is extremely small and the protein content extremely large, their palatability is likely to be low relative to the newer formulations that include at least 10% of energy as milk. Unfortunately, no data on the intake of these older formulations are available.

Commercial availability and urbanization trends

The availability of high-quality, low-cost fortified complementary foods on the commercial market is almost negligible in the developing world.* Nearly 50% of the developing world's population is urban, and the trend is toward increasing urbanization (fig. 1) [12]; in Latin America it is nearly 80% (fig. 2). Urban populations purchase a large proportion of their food and rely on a cash economy far more than rural populations. In Accra, Ghana, more than 90% of the food consumed was purchased [13]. In comparison with women in rural areas, women in urban areas are more likely to work outside the home, to receive wages for their work, and to be the head of the household [12]. All these factors limit their time for cooking and caring for their children, with particular constraints on the time availa-

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* Although brand-named, fortified complementary foods are available in major supermarkets in most urban centers, their price makes them inaccessible to all but the most highly affluent customers.
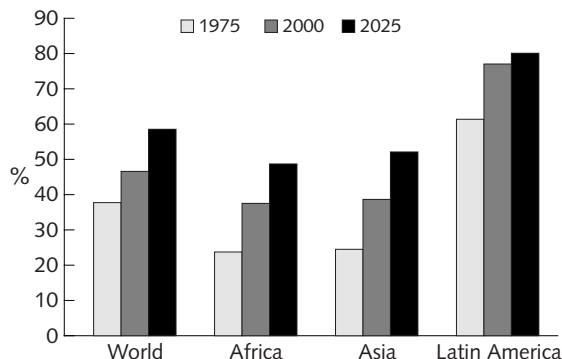

FIG. 1. Percentage of the population living in urban areas according to region and year (1975–2025)
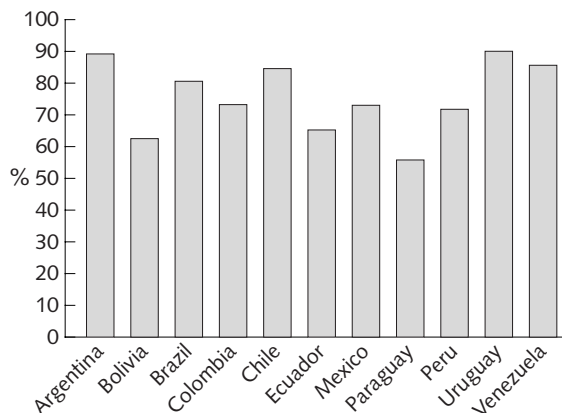

FIG. 2. Percentage of the population living in urban areas in selected Latin American countries in 2000

ble for them to prepare nutrient-dense complementary foods for their older infants and young children.

In the past, public institutions concerned with nutrition have introduced a large number of low-cost fortified complementary foods into the commercial market. However, few have experienced sufficient demand to become profitable, and they have nearly all failed to improve the availability of fortified complementary foods through the commercial sector. A notable exception to these market failures is Incaparina [14], which was developed by the Institute of Nutrition of Central America and Panama (INCAP) and continues to be widely consumed in Guatemala.* In a recent study in both a poor periurban mestizo population and a rural indigenous one, infants and toddlers consumed Incaparina for a period of 15 days in the previous month [15], indicating that it is widely accepted in both urban and rural areas and among the indigenous community.

Creating demand

Concern for consumer demand, a key element in any market approach, has been missing in previous strategies to improve access to high-quality fortified complementary foods. As summarized by Mora [16], consumers are attracted to commercial products that meet their perceived needs; are of good quality—though not necessarily nutritional—regarding some functional properties such as texture, color, flavor, ease of preparation, and preservation; and are reasonably priced. Low-income consumers do not behave differently from other consumers except that the price is of critical importance and functions as a gatekeeper to access. Many snack foods of poor nutritional quality that meet the above criteria are now consumed in the developing world, even by low-income groups. Consumer demand for processed foods is growing with urbanization, thus favoring a commercial approach with respect to fortified complementary foods.

The perceived needs of consumers can be modified through education and social marketing interventions aimed at enhancing awareness of health and nutrition [17]. In public health this has been best exemplified by the social marketing of contraceptives, oral rehydration salts, and iodized salt. However, the demand for improved complementary feeding strategies and complementary foods is a necessary condition to support a market-based approach.

Working with the private sector

Fortification of staple foods

Interest in working with the private sector to improve the micronutrient status of the population is increasing. In staple-food fortification it has been possible to reconcile the health interests of the public sector with the economic interests of the private sector within a strong legislative and regulatory framework so that both sectors and the population at large benefit. The many successful experiences throughout the world—coupled with the fact that such programs, once implemented, are self-financing—have resulted in a high level of international technical and financial support for the promotion, implementation, and monitoring of staple-food fortification.

Implications for fortification of complementary foods

Although the steps involved in the promotion of fortified complementary foods through the commercial sector have some similarities to those of staple-food fortification, there are some fundamental differences. Unlike staple foods, there is no commercial market for fortified complementary foods among low- and middle-income consumers, and such a market would have to be developed.*Also, excess in the use of fortified complementary foods has the potential to impact negatively on the practice of breastfeeding and the use of traditional complementary foods, especially their preparation in a manner (usually from excessive dilution or poor hygiene) that undermines rather than promotes good nutrition. A key challenge, therefore, is how to generate a positive policy and legislative environment that encourages the production and marketing of such foods at affordable prices. At the same time, this policy and legislative environment must ensure that breastfeeding is protected, foods are correctly prepared and stored, and consumers are not left with the impression that only a particular brand can meet the needs of their children or that local foods are not also important.

Private-sector production of complementary foods used in public programs

In the public sector, many of the fortified complementary foods used in feeding programs are produced and distributed by the private sector under contract to national governments or international agencies [6]. The World Food Program (WFP), USAID, and national governments have recognized the advantage of using the food industry to produce and distribute fortified complementary foods. Quality control is ensured

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* Although it was not developed as a fortified complementary food, Incaparina is fed to children in the targeted age range as well as to other family members. At present the production, quality control, and distribution of Incaparina rest with Alimentos SA, a private firm that has the rights to the product [14].

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* The lack of a market for fortified complementary foods reflects, in part, the general lack of recognition by parents, health providers, and government leaders of the critical importance of complementary feeding to child health and social and economic development.

and appropriate messages about breastfeeding and complementary feeding are included by using clearly written and enforceable contracts. This is in contrast to the previous emphasis on the production by national governments or the WFP, where state-owned and operated factories were set up for the purpose of producing complementary foods. In Colombia, the three government-owned factories have been leased through a competitive bidding process to the private sector for the production of Bienestarina, which is used widely in public-sector programs. Since 1991, the WFP has also shifted its focus to work with private-sector companies in Bangladesh, Eritrea, Ethiopia, India, Kenya, Malawi, Nepal, Nicaragua, Senegal, Uganda, and Zambia, with excellent results [18].

Potential role of the private sector in the commercial market

The private sector can potentially play an important role in developing and marketing high-quality, low-cost fortified complementary foods, similar to their role in staple-food fortification. To do this, however, requires generating consumer demand for such products. Also, the different objectives and responsibilities of the private and public sectors must be recognized and maintained because they have the potential to be in conflict, as has been well documented in the marketing of infant formula (including follow-on formulas) and related products [19–21]. Private-sector companies have a strong incentive not to market unsafe foods, otherwise they would cease to exist. However, this is not necessarily the same as producing a high-quality product at an economically accessible price and marketing it in a way that also promotes optimal breastfeeding and other complementary feeding practices, which are consistent with the objectives of the public sector.

Scientific considerations

Nutritional composition of fortified complementary foods and costs

Macronutrient composition

The nutritional characteristics of fortified complementary foods have improved over time [6] (table 1). Foods formulated in the 1990s have a higher content of fat and a lower content of protein than foods formulated in the 1970s and 1980s, and they reflect changes in scientific knowledge about the nutritional needs of infants and young children. The protein content of the recently formulated foods from Ecuador, Mexico, and Peru is less than 15 g per 100 g of dry product, as compared with approximately 25 g per 100 g of dry product for the Guatemalan and Colombian foods that were formulated in the 1970s and 1980s. The fat content of the Peruvian food is nearly 15 g per 100 g of dry product, as compared with less than 2 g per 100 g of dry product

in the Colombian foods. Thus, the recently formulated foods have a higher energy and nutrient density than the foods formulated prior to the 1990s.

Micronutrient composition

The content of micronutrients also varies considerably across different foods and is best considered in terms of daily ration size. This varies from 90 g per day in the food from Peru to 39 to 56 g in Incaparina (depending on the number of servings consumed; the package recommends two to three servings of 18.75 g) (table 2). Although iron is routinely added to all foods, the content per daily ration ranges from 10 mg in the food from Mexico to 4 mg in Incaparina (fig. 3). Also, the iron compound, which determines bioavailability, varies among the different foods. To further complicate the comparison of iron content and bioavailability, the amount of ascorbic acid, which promotes the absorption of some iron compounds, ranges from 20 to 92 mg per 100 g of dry product. As a result, foods with the same iron content and iron compound may have very different amounts of bioavailable iron.

Zinc, identified as another problem nutrient by the World Health Organization (WHO) [3], is also highly variable (fig. 4). It is not routinely added to Incaparina or to Bienestarina, one of the foods from Colombia. Its content is close to 10 mg per daily ration in the more recently formulated foods, as compared with less than 3 mg in the older formulations. The vitamin A content ranges from 38 μg RE (retinol equivalents) per daily ration in the food from Ecuador to 649 μg RE in the food from Peru (fig. 5). The calcium content ranges from nearly 400 mg per daily ration in the Title II USAID/WFP program to 114 mg in Incaparina.
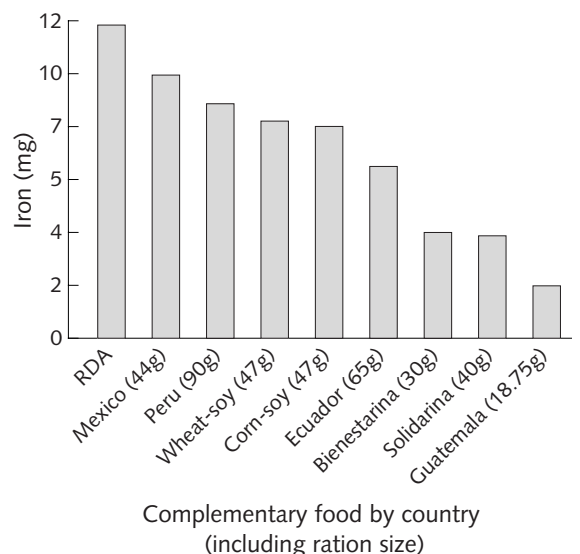

FIG. 3. Iron content of complementary foods

TABLE 1. Summary of the nutritional characteristics of fortified complementary foods and cost of foods used in Latin America per 100 g of dry product[a]

Energy and nutrients	Ecuador (US$0.14) Mi Papilla	Peru (US$0.21) Alli Alimentu	Mexico (US$0.18) Nutrisano	Guatemala Inca-parina[b]	USAID/WFP Wheat-soy blend[c]	USAID/WFP Corn-soy blend[c]	Colombia (US$0.07) Bienesta-rina	Colombia (US$0.07) Colombia-rina	Colombia (US$0.07) Solidarina
Energy (kcal)	423	444	440	375	355	376	319	383	340
Protein (g)	16.0	14.4	13.3	21.3	21.5	17.2	26.0	21.7	23.0
Fat (g)	10.0	14.8	—	5.3	5.9	6.9	1.4	1.3	2.0
Vitamins									
Vitamin A (µg RE)	127	720	921	1,351	698	784	601	1,502	520
Biotin (µg)	—	—	—	—	—	—	—	—	—
Folic Acid (µg)	50	30.0	115	—	275	300	—	—	170
Niacin (mg)	5.4	5.0	—	13.6	8.2	6.2	9.7	13.3	6.6
Panthothenic acid (mg)	—	—	—	—	3.7	3.4	—	—	—
Riboflavin (mg)	0.48	0.5	1.8	1.0	0.5	0.5	0.5	1.1	0.5
Thiamine (vitamin B_1) (mg)	0.42	0.5	—	1.7	0.5	0.5	2.0	1.8	0.4
Vitamin B_6 (mg)	0.6	0.6	—	—	0.5	0.5	—	—	—
Vitamin B_{12} (µg)	0.7	0.5	1.6	—	1.0	1.0	—	—	1.7
Vitamin C (mg)	24	50	92	—	40	40	27	—	29
Vitamin D (µg)	—	—	—	—	198	198	—	—	0.4
Vitamin E (mg)	3.6	—	13.8	—	8.7	8.7	2.1	1.8	0.4
Vitamin K (µg)	—	—	—	—	—	—	—	—	—
Minerals									
Calcium (mg)	240	200	—	305	842	831	512	500	568
Chloride (mg)	—	—	—	—	—	—	—	—	—
Copper (mg)	—	—	—	—	—	—	1.1	—	—
Fluoride (mg)	—	—	—	—	—	—	—	—	—
Iodine (µg)	—	70	—	—	56	57	—	—	—
Iron (mg)	10	10.0	23.0	11.2	17.9	17.5	14.1	14.2	10.0
Magnesium (mg)	48	50	—	—	227	174	140	—	—
Manganese (mg)	—	—	—	—	—	—	—	—	—
Phosphorus (mg)	240	200	—	65	294	206	766	275	440
Potassium (mg)	—	—	—	—	—	—	—	—	—
Selenium (µg)	—	—	—	—	—	—	—	—	—
Sodium (mg)	—	—	—	—	—	—	—	—	—
Zinc (mg)	10	10.0	23.0	—	5.5	5.0	1.8	8.3	6.0

a. A dash indicates that the product was not fortified with the nutrient. However, the nutrient may be present if it occurs naturally in the macro ingredients. Costs include those of production and distribution to the community, though not to the beneficiary.
b. Assumes two servings per day at 18.75 g per serving.
c. Amount of nutrient in the product occurring both in the macro ingredients and through fortification.

Costs

The cost of the fortified complementary foods varies widely and has increased over time. The increased costs are largely due to the higher fat content in the newer foods, which is often supplied by dried milk. The Ecuadorian, Mexican, and Peruvian foods cost, respectively, US$0.14, 0.18, and 0.21 per 100 g of dry product for production and distribution.* In contrast, the Colom-

bian food costs US$0.07 per 100 g of dry product. The retail price of Incaparina is US$0.17 for a 75-g bag and US$0.55 for a 454-g bag, indicating that the

* These figures are not strictly comparable, in that one of

the objectives of the program in Peru is to stimulate local agricultural production. Therefore, all macro ingredients have to be purchased locally and manufacture also has to be local, so that the production is not truly competitive. The plants currently producing the Peruvian food do not have other commercial purposes and would cease to exist in the absence of the program.
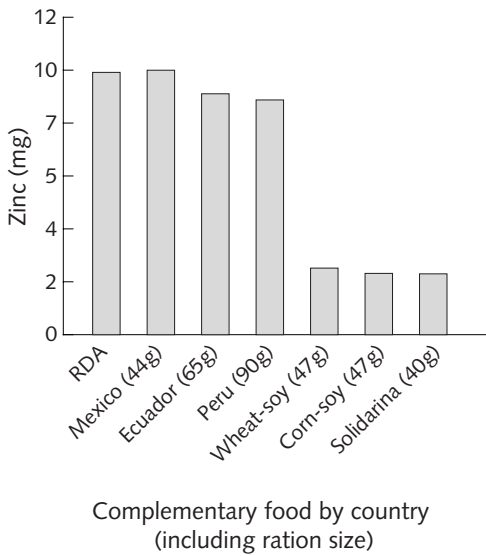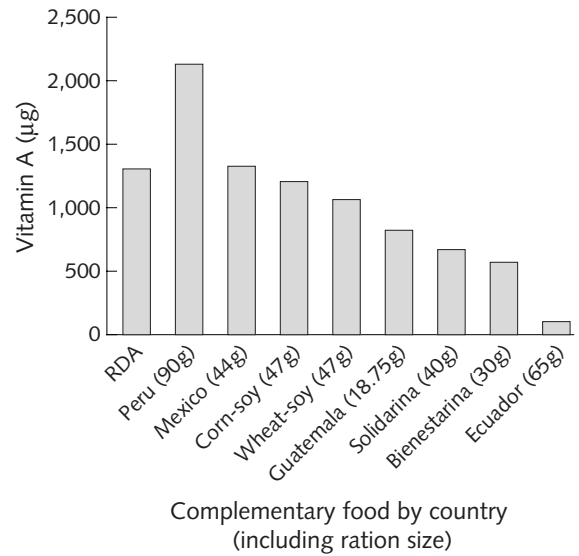
FIG. 4. Zinc content of complementary foods

FIG. 5. Vitamin A content of complementary foods

production costs are considerably lower [15]. The cost of micronutrients is very small relative to the cost of the macronutrients in fortified complementary foods [23]. However, the overall cost of these foods can be high relative to the purchasing power of the consumer, depending on the composition of the macronutrients. Therefore, cost considerations in formulation development are critical.

However, cost must also be considered in the context of nutrient density and, in the case of foods provided through the public sector, the amount that the beneficiary actually consumes. For example, Bienestarina (Colombia) is produced at half the cost of Mi Papilla (Ecuador)—US$0.07 versus US$0.14 per 100 g—and Bienestarina provides only 1.5 times the kilocalories per dollar because it is high in protein relative to fat. Per dollar, Bienestarina provides only 62 g of fat, whereas Mi Papilla provides 71 g of fat. Fat content is important because of the role of essential fatty acids in brain development, the positive influence of fat on the absorption of some micronutrients, and its role in improving the palatability of the food, which is likely to affect the amount consumed. No information is available on the consumption of the less expensive low-fat-content foods; however, the consumption of the foods from Mexico and Peru is acceptable.

Development of a recommended nutrient composition

The development of a recommended nutrient composition for fortified complementary foods requires consideration of both biological and nonbiological factors. Important biological factors include the following:

» The age range and nutrient requirements of the target group

» The amount of breastmilk consumed, if any, by this group and whether the contribution of breastmilk should be considered in developing a recommended formulation
» The proportion of total requirements that should be provided by a fortified food
» The ration size
» The potential for micronutrient interactions
» The bioavailability of the compounds used and the enhancing properties of other micronutrients

Nonbiological factors include those related to food technology vis-à-vis the feasibility of manufacturing the recommended physiological optimum, whether the product is instant or requires cooking, its organoleptic properties (those related to taste and sensory aspects), packaging and transport considerations, expected storage time, and cost.

Consideration of the biological factors leads to the formulation of a nutrient composition that is physiologically optimal for the infant and young child. Consideration of the nonbiological factors is necessary to determine how the micronutrient content should vary, taking into account losses due to cooking (if required), storage, and packaging.

Age group and daily ration size

One formulation versus age-specific formulations. A fundamental question in developing a recommended nutrient formulation is whether to recommend one formulation or age-specific formulations. Over the age range under consideration (6 to 24 months), the intake of complementary foods ranges from less than 25 g to more then 250 g of dry food per day [4]. The intake depends on age (which in turn is related to body size and energy requirements) and breastmilk intake. Therefore, a major challenge is to ensure that

TABLE 2. Summary of nutritional requirements, ration sizes, and nutritional characteristics per ration size of fortified complementary foods in Latin America[a]

Energy and nutrients	Dietary reference values [3][b]		Ecuador	Peru	Mexico	Guatemala	USAID/WFP		Bienestarina	Colombia	
	6–11 mo	12–24 mo	Mi Papilla	Alli Alimentu	Nutrisano	Incaparina[b]	Wheat-soy blend[c]	Corn-soy blend[c]		Colombia-rina	Solidarina
Ration size	—	—	65	90	44	37.5–56.25	47	47	30	NA	40
Energy (kcal)[d]	750 (255)	894 (548)	275	400	194	140–210	167	177	96	—	136
Protein (g)	9.4	10.9	16	13.0	5.8	8.0–12.0	10.0	17.2	7.8	—	9.2
Fat (g)	—	—	6.5	12.0	NA	2.0–3.0	2.8	3.2	0.4	—	0.8
Vitamins											
Vitamin A (µg RE)	350	400	83	628	400	810–1,215	328	369	180	—	208
Biotin (µg)	—	—	—	—	—	—	—	—	—	—	—
Folic Acid (µg)	32	50	32.5	27	50.0	—	129	141	—	—	68
Niacin (mg)	5	8	3.5	4.5	—	5.1–7.65	3.9	2.9	2.9	—	—
Panthothenic acid (mg)	—	—	—	—	—	—	1.7	1.6	—	—	—
Riboflavin (mg)	0.4	0.6	0.31	0.45	0.8	0.38–0.56	0.24	0.24	0.24	—	2.6
Thiamine (vitamin B_1) (mg)	0.3	0.5	0.3	0.45	—	0.64–0.96	0.24	0.24	0.6	—	0.2
Vitamin B_6 (mg)	0.4	0.7	0.4	0.54	—	—	0.24	0.24	—	—	—
Vitamin B_{12} (µg)	0.4	0.5	0.46	0.45	0.7	—	0.47	0.47	—	—	0.9
Vitamin C (mg)	25	30	16	45	40	—	19	19	8.1	—	11.6
Vitamin D (µg)	7	7	—	—	—	—	93	93	—	—	0.2
Vitamin E (mg)	—	—	2.3	—	6.0	—	4.1	4.1	0.6	—	0.2
Vitamin K (µg)	—	—	—	—	—	—	—	—	—	—	—
Minerals											
Calcium (mg)	525	350	156	180	—	114–172	396	391	154	—	227
Chloride (mg)	500	800	—	—	—	—	—	—	—	—	—
Copper (mg)	0.3	0.4	—	—	—	—	—	—	0.3	—	—
Fluoride (mg)	—	—	—	—	—	—	—	—	—	—	—
Iodine (µg)	60	70	—	63	—	—	26	27	—	—	—
Iron (mg)—bioavailability											
Low	21	12									
Medium	11	6	6.5	9.0	10.0	4.2–6.3	8.4	8.4	4.2	—	0.4
High	7	4									
Magnesium (mg)	80	85	31	45	—	—	107	82	—	—	—

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Manganese (mg)	—	—	—	—	—	—	—	—	—	—	—
Phosphorus (mg)	400	270	156	180	—	24–37	138	97	230	—	176
Potassium (mg)	700	800	—	—	—	—	—	—	—	—	—
Selenium (µg)	10	15	—	—	—	—	—	—	—	—	—
Sodium (mg)	350	500	—	—	—	—	—	—	—	—	—
Zinc (mg)	5.0 (UK) / 2.8 (WHO)	6.5 (UK) / 2.8 (WHO)	6.5	9.0	10.0	—	2.6	2.6	0.5	—	2.4

a. A dash indicates that the product was not fortified with the nutrient. However, the nutrient may be present if it occurs naturally in the product.
b. Unless otherwise noted, Dietary Reference Values are from the United Kingdom (Department of Health 1991).
c. Amount of nutrient in the product occurring both in the macro ingredients and through fortification.
d. Based on a longitudinal study of healthy US children [22]. The first figure is the total daily energy requirement. The figure in parentheses is the estimated amount of energy required from complementary foods, assuming average breastmilk intake.

the nutrient needs of both infants aged 6 to 11 months and young children aged 12 to 23 months are met. In general, infants consume the smallest amounts of complementary food. However, depending on the nutrient in question, their specific nutrient needs might be as great as or greater than those of children aged 12 to 23 months because of their rapid rate of growth and development. Because infants consume less food, ensuring nutrient adequacy for them requires a higher nutrient density or amount of nutrient per 100 kcal. However, a formulation that ensures an optimal nutrient density for infants could result in excessive intakes of some nutrients by children aged 12 to 23 months, because of their greater consumption. For example, a food developed for children aged 12 to 23 months is likely to be inadequate to meet the requirements of infants aged 6 to 8 months for calcium, iron, and zinc [4]. At the same time, a food developed for infants aged six to eight months results in intakes of calcium, iron, and zinc that are too high for older children.

Role of breastfeeding. Breastfeeding status and the contribution of breastmilk toward meeting a recommendation is a key factor in the determination of a desired micronutrient density in a fortified complementary food. This is best illustrated by looking at the proportion of micronutrients needed from complementary foods, assuming an average breastmilk intake (table 3). Breastfeeding status is not important for nutrients such as iron and zinc, for which breastmilk makes a small contribution toward the total requirement. For these nutrients, nearly the entire requirement must be met by complementary foods. However, for nutrients such as vitamin A, the contribution of breastmilk is variable but can be quite large if a mother has an adequate level of vitamin A and her infant consumes an average amount of breastmilk. Among nonbreastfed children, and children whose mothers have poor vitamin A status and who consume low amounts of breastmilk, a significantly greater proportion of the vitamin A requirement would need to be met by complementary foods.

A conservative approach, which is the one recommended here, is to develop a formulation that meets the largest possible proportion of micronutrient needs of nonbreastfed or minimally breastfed children. At the same time, it is necessary to ensure that the proposed level of any micronutrient does not put children who consume an average or a large amount of breastmilk from well-nourished mothers at risk of excessive intake of the micronutrient. This may require reducing the level of fortification.

Recommended daily ration size. The recommended daily ration size (in grams of dry product) is the starting point in developing a recommended nutrient composition, because it determines the volume of food to which the recommended levels of micronutrients are added. Because the recommended amounts of fat, car-

TABLE 3. Estimated daily nutrient needs from complementary foods by average breastmilk intake[a]

	Breastmilk average		
Nutrient	6–8 mo	9–11 mo	12–23 mo
Protein (g)	2	3.1	5
Vitamin A (μg RE)	13	42	126
Folate (μg)	0	0	3
Niacin (mg)	3	4	7
Pantothenic acid (mg)	0.5	0.6	0.7
Riboflavin (mg)	0.2	0.2	0.4
Thiamine (mg)	0.1	0.2	0.4
Vitamin B_6 (mg)	0	0	0
Vitamin B_{12} (μg)	0	0	0
Vitamin C (mg)	0	0	8
Vitamin D (μg)	606	6.7	6.7
Vitamin K (μg)	9	9	9
Calcium (mg)	336	353	196
Chloride (mg)	217	241	569
Copper (mg)	0.1	0.1	0.3
Fluoride (μg)	0	0	0
Iodine (μg)	0	0	10
Iron (mg)—bioavailability			
Low	20.8	20.8	11.8
Medium	10.8	10.8	5.8
High	6.8	6.8	3.8
Magnesium (mg)	51	58	66
Manganese (μg)	12	12	13
Phosphorus (mg)	306	314	193
Potassium (mg)	346	377	512
Selenium (μg)	0	0	4
Sodium (mg)	199	239	401
Zinc (mg)[b]	4.2	4.3	5.8
Zinc (mg)[c]	2.2	2.3	2.4

a. Source: adapted from table 26 in ref. 3.
b,c. Zinc needs from complementary foods have been estimated in two ways indicated by superscripts b and c. The basis for these formulations is described in detail in ref. 3.

bohydrate, and protein are based on proportions, they do not vary with ration size. The recommended daily ration size should be based on empirical data on the age-specific amount of fortified complementary food consumed in grams and kilocalories and the contribution (as a proportion in grams and kilocalories) this represents of the total daily diet. This level of precision could be obtained by either a 24-hour recall or weighed intake. Ideally, such empirical data would be obtained in numerous different settings and at a time several months after the introduction of the food. This would ensure that the novelty of the food was not a factor in the measurement and that the measurement reflected the intake of the complementary food in the context of the usual diet and breastfeeding patterns.

Despite the large number of programs that use

fortified complementary foods, there are few data on the actual amount consumed that would provide an empirical basis for developing a recommended daily ration size. Only three studies that provided information on the energy obtained from consumption of fortified complementary foods were identified, in Ghana, Mexico, and Peru. In all three the food was provided free of charge to the study or program participants, and in only one were data obtained well after the introduction of the food (11 months) and in the context of total daily consumption. In this study, in Peru, data were collected in the context of the evaluation of a social development program [9], whereas in Mexico the data were collected as part of an acceptability trial [24] and in Ghana as part of an efficacy study.

In Peru, children aged 12 to 23 months consumed 67.3 ± 34.4 g of the daily ration of 90 g of the complementary food. This amount corresponded to 302.3 ± 153 kcal out of a total of 596.8 ± 275.4 kcal consumed (personal communication, López Preciado T, Consultant, Lima, Peru, 2002) and provided 51% of the children's energy consumption. However, only 69 of the 110 children who received the fortified complementary food actually consumed any of the food on the day prior to the interview and were included in the estimate. Also, neither breastfeeding status (yes or no) nor the amount of breastmilk consumed was considered in the estimate.

In Ghana, data from an efficacy study showed that infants aged six to eight months obtained 150 kcal from a complementary food (30 g of dry product), corresponding to 71% of their requirement from complementary foods, assuming an average breastmilk intake [3] (personal communication, Dewey K, Department of Nutrition, University of California, Davis, Calif., USA, 2001). Infants aged 9 to 11 months obtained 170 kcal (from 35 g of dry product), corresponding to 53% of their requirement, again assuming an average breastmilk intake.

In Mexico, data from a two-week acceptability trial showed that infants aged 6 to 11 months consumed 45.1 ± 17 g and children aged 12 to 23 months consumed 52.0 ± 16.9 g of the complementary food (personal communication, Rivera J, Department of Maternal and Child Health and Nutrition, National Institute for Public Health, Cuernavaca, Mexico, 2001). Information is not available from either the Ghanaian or the Mexican studies on the total consumption and the proportion of total energy (in grams and kilocalories) the intakes represent.

Given the data presented above, it seems reasonable to estimate a daily ration of 40 g for infants aged 6 to 11 months and 60 g for young children aged 12 to 23 months. If only one formulation were to be recommended, a daily ration size of 50 g would seem reasonable. However, more data on consumption are needed to improve the basis for these estimations.

Source of data for recommended intakes

Micronutrients. Selecting the appropriate daily requirement of micronutrients for infants and young children aged 6 to 24 months is a challenging task, since there are several different sources of information, each one using different methodologies in their development (table 4). In the United States, the dietary reference intakes (DRIs) published recently by the Institute of

TABLE 4. Infant and young child nutrient requirements: comparison of dietary reference values from the UK and dietary reference intakes from the US National Academy of Sciences[a]

Nutrient	Dietary reference values (UK)		Dietary reference intakes (US)	
	6–11 mo	12–24 mo	7–12 mo	1–3 yr
Vitamins				
Vitamin A (µg RE)	350	400	500	300
Biotin (µg)	—	—	6	8
Folate (µg)	32	50	80	150
Niacin (mg)	5	8	4	6
Panthothenic acid (mg)	—	—	1.8	2
Riboflavin (mg)	0.4	0.6	0.4	0.5
Thiamine (mg)	0.3	0.5	0.3	0.5
Vitamin B_6 (mg)	0.4	0.7	0.3	0.5
Vitamin B_{12} (µg)	0.4	0.5	0.5	0.9
Vitamin C (mg)	25	30	50	15
Vitamin D (µg)	7	7	5	—
Vitamin E (mg)	–	–	5	6
Vitamin K (µg)	—	—	—	—
Minerals				
Calcium (mg)	525	350	270	500
Chloride (mg)	500	800	–	–
Copper (mg)	0.3	0.4	–	–
Fluoride (mg)	—	—	0.5	0.7
Iodine (µg)	60	70	—	—
Iron (mg)— bioavailability				
Low	21	12	—	—
Medium	11	6	—	—
High	7	4	—	—
Magnesium (mg)	80	85	75	80
Manganese (mg)	—	—	—	—
Phosphorus (mg)	400	270	275	460
Potassium (mg)	700	800	—	—
Selenium (µg)	10	15	20	20
Sodium (mg)	350	500	—	—
Zinc (mg)	5.0 (UK) 2.8 (WHO)	6.5 (UK) 2.8 (WHO)	—	—

a. Source: refs. 25–29.

Medicine (IOM) provide recommendations for most micronutrients for infants and young children [25–28]. The DRIs are sets of recommendations that include the following: estimated average requirement (EAR), recommended dietary allowance (RDA), adequate intake (AI), and tolerable upper intake level (UL). The EAR reflects "the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage or gender group" [28]. They are used as the basis for setting the RDA, which is defined as "the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97–98%) healthy individuals in a particular life stage and gender group" [28]. RDAs are set at two standard deviations (SD) above the EAR. The adequate intake (AI) is defined as "a recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate—used when an RDA cannot be determined." The UL is defined as "the highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in the general population" [28].

Because of the paucity of data on nutrient requirements for infants and young children, all recommendations (except iron and zinc) for infants aged 7 to 12 months, and some of the recommendations for young children aged one to three years, are based on AIs. However, because AIs are derived from studies examining the diets of healthy children from developed countries, many of whom consume fortified infant foods, they potentially overestimate the actual requirement. For children aged one to three years, most of the recommendations are based on RDAs that have been extrapolated from other age groups. These two different methods for estimating the DRIs have led to inconsistencies in the recommendations for some nutrients across the two age groups.

The recommendation for vitamin A illustrates this problem. An AI of 500 µg RE has been set for the 7- to 12-month age group and an RDA of 300 µg RE for the age group from one to three years. There is no biological basis for setting a higher requirement for vitamin A in the first year of life than in the second. Rather, the reference intakes reflect the different methodologies and sources of data used in their development. To further complicate the picture, the UL is set at 600 µg RE, which is only 100 µg RE above the AI for the younger age group. Given that the contribution of vitamin A from breastmilk is highly variable and the fact that some children will be receiving no breastmilk, determining the desired content of vitamin A in a fortified complementary food is a challenge.

Another source of dietary requirements frequently used for infants and young children is the recommended nutrient intakes (RNIs) from the dietary ref-

erence values from the United Kingdom Department of Health [29]. These are used as the basis for complementary feeding guidelines [3, 4] for most nutrients. RNIs are based on the estimated average requirements plus 2SD and are derived by the factorial method.

Macronutrients. The energy requirement for infants and young children has been decreasing over the past several decades, reflecting new scientific techniques that permit the evaluation of requirements based on energy expenditure and deposition rather than observed intakes. The most recent data are based on longitudinal measures of total energy expenditure and energy deposition from 76 healthy children at 3, 6, 9, 12, 18, and 24 months of age living in Houston, Texas, USA [22]. Among these children, the energy requirements differed by age, breastfeeding status, and sex. Once adjusted for weight, they differed only by breastfeeding status, with the energy requirements for breastfed infants in the age range of 6 to 24 months approximately 4% to 5% less than those for non-breastfed infants. These new estimates are about 5% to 18% less than those in the 1998 WHO report [3] when expressed as a function of age, and about 5% to 13% less when expressed as a function of body weight. They are about 20% less than the Food and Agriculture Organization (FAO)/WHO recommendations [30], which are currently being revised in the light of new data and will be released shortly.

The new energy requirements are 615, 686, and 894 kcal per day for the age groups from 6 to 8, 9 to 11, and 12 to 23 months, respectively (table 5). The average breastmilk intakes are 413 kcal for infants aged 6 to 8 months, 379 kcal for infants aged 9 to 11 months, and 346 kcal for young children aged 12 to 23 months [3]. Therefore, the energy requirements from complementary food are 202, 307, and 548 kcal for the age groups from 6 to 8, 9 to 11, and 12 to 23 months, respectively. These can be rounded off to 200 kcal for infants aged 6 to 8 months, 300 kcal for infants aged 9 to 11 months, and 550 kcal for young children aged 12 to 23 months.

With the use of these revised energy requirements and on the assumption of an energy density of 440 kcal per 100 g of dry product, the recommended daily ration sizes provide 87%, 57%, and 48% of the energy needs of infants and young children aged 6 to 8, 9 to 11, and

12 to 23 months, respectively. This assumes that the daily ration size is 40 g for infants aged 6 to 11 months and 60 g for young children aged 12 to 23 months, and that all children are consuming an average amount of breastmilk for their age group. The inverse relationship between the proportion of energy requirements that are met and age makes sense, since the children gradually consume a greater and greater proportion of their complementary foods from the family diet.

Recommended nutrient composition

Iron and ascorbic acid. Iron stores in the liver at birth play a major role in determining iron status and the risk of anemia during the first six months of life. The risk of iron deficiency during this period is generally low among infants of normal birthweight. Among infants of low birthweight, the risk is much greater, and medicinal iron drops are recommended starting at two to three months [32]. The iron in breastmilk, although highly bioavailable, is low in concentration and provides only a very small proportion of the iron requirements. Therefore, after the age of six months, nearly all iron must come from complementary foods. It has been estimated that complementary foods need to provide 97% of the iron requirements for infants aged 9 to 11 months [33].

Complementary diets generally are low in iron [3]. This is because they are primarily cereal-based and include a small proportion, if any, of meat products that provide heme iron, the most bioavailable source of iron and one that also enhances the absorption of iron from nonmeat sources. Cereal-based complementary foods are not good sources of iron because of their high phytate content [34].

A fortified complementary food should provide a quantity of iron sufficient to ensure that the food meets the US Recommended Dietary Allowance (RDA) of 11 mg for infants aged 7 to 12 months and 7 mg for toddlers [35]. The compound used should also have a bioavailability of at least 10%. To enhance iron absorption, ascorbic acid should be added in quantities of 70 to 140 mg per day for infants aged 6 to 11 months and 50 to 100 mg per day for young children aged 12 to 23 months. These amounts are in excess of the requirement for ascorbic acid but pose no risk of toxicity. Dried ferrous sulfate of small particle size is the rec-

TABLE 5. Energy requirements from complementary foods according to age group, based on longitudinal studies of US children[a]

Age group (mo)	Total energy requirements (kcal)	Milk energy intake (kcal)	Energy required from complementary foods (kcal)
6–8	615	413	202
9–11	686	379	307
12–23	894	346	548

a. Source: ref. 31.

ommended iron compound, because the absorption-enhancing effects of ascorbic acid on this compound have been established [35].

Zinc and copper. For infants aged 7 to 12 months and young children aged one to three years, the new EAR for zinc is 2.5 mg and the new RDA is 3 mg. The UL is 5 mg for infants aged 7 to 12 months and 7 mg for children aged one to three years. However, the fractional absorption of zinc as measured in Mexico (0.32 to 0.37) is lower than the figure of 0.41 to 0.48 used in calculating the DRIs in the United States. The lower estimated fractional absorption found in Mexico is likely to be similar to that in other countries in Latin America, where diets are primarily plant based. Therefore, the recommended level of zinc in a fortified complementary food is 4 to 5 mg [36]. Zinc oxide is the most commonly used compound because it is well absorbed, produces no organoleptic changes, and is significantly less expensive than other zinc compounds [36]. Copper is not currently added to most complementary foods. The AI for copper is 220 µg for infants aged 7 to 12 months. The EAR and RDA for children aged one to three years are 260 and 340 µg, respectively. No UL has been set for infants; the UL is 1 mg for children aged one to three years. The recommended level of fortification is 200 to 400 µg [36].

Calcium, vitamin D, magnesium, and phosphorus. In the United States, the AIs for calcium for infants aged 7 to 12 months and for young children aged one to three years are 270 and 500 mg per day, respectively [25]. These differ from the UK dietary reference values, which are 525 and 350 mg per day for infants aged 7 to 12 months and for young children aged 12 to 23 months, respectively [33]. The estimated calcium retention is 50% for breastmilk and ranges from 20% to 25% for solid foods [37]. Among infants aged 7 to 12 months, an estimated 130 mg of calcium is obtained from breastmilk, leaving another 140 mg needed from complementary foods [37]. Children aged 12 to 23 months obtain an estimated 100 mg of calcium from breastmilk. Another 250 mg per day from food would be needed to ensure a calcium retention of 100 mg per day. A calcium intake of 350 mg per day is consistent with the recommendations from the United Kingdom, although lower than the US recommendations [37].

Based on the analysis above, Abrams and Atkinson [37] recommend a level of calcium fortification of 100 to 200 mg per daily ration. This amount is safe and could be incorporated into the food with no undesirable organoleptic changes. For infants and young children who are not breastfed or who are receiving nonhuman milk, this level of fortification is not likely to meet their entire requirement, but it would effectively help prevent calcium deficiency. The calcium compound used does not appear to be a critical issue with respect to bioavailability [37].

In the United States, the AI of magnesium for infants aged 7 to 12 months is 75 mg per day [25]. For young children aged one to three years, interpolation of data from older children gives an RDA of 80 mg. Although magnesium does not appear to be limited in Latin American diets, fortification of foods with calcium in the absence of magnesium is controversial [37]. The addition of 40 to 60 mg of magnesium per daily ration is very unlikely to have side effects, but it cannot be advocated until further research is conducted to better characterize the magnesium needs of small children [37]. In the United States, the AI of phosphorus for infants aged 7 to 12 months is 275 mg per day. The factorial method was used to set an RDA of 460 mg per day for children aged one to three years. The diets of infants and young children do not appear to be limited in phosphorus, and routine fortification of complementary foods is not likely to be necessary [37]. However, if fortification were to be undertaken, a level of 75 to 100 mg per daily ration would be reasonable.

There is little vitamin D in breastmilk, and the importance of dietary sources of this vitamin is increasingly recognized, particularly among populations with dark skin who receive little exposure to sunlight and who do not have access to vitamin D–fortified products [37]. The AI for infants aged 7 to 12 months and children aged one to three years is 5 µg [25]. A level of fortification of 1 to 2 µg per daily ration is recommended and would be safe [37].

Vitamin A. The Dietary Reference Values for vitamin A in the United Kingdom are 350 and 400 µg RE for infants aged 6 to 11 months and children aged 12 to 24 months, respectively [29]. The AIs set in the United States are 500 µg RE for infants aged 6 to 12 months and 300 µg RE for children aged one to three years [28]. The safe upper limit has been set at 600 µg RE. Among well-nourished women, breastmilk is an important source of vitamin A, meeting between 40% and 75% of the AIs for infants and young children aged 6 to 24 months [38]. Nonbreastfed children who do not receive vitamin A from meat sources may not receive sufficient provitamin A carotenoids from plant sources, particularly given their lower bioavailability from plants than was previously calculated. However, meeting the needs of nonbreastfed children with a fortified food, while at the same time ensuring that breastfed children do not receive too much vitamin A, is a challenge because of the relatively low level of vitamin A that has been declared as the safe upper limit (600 µg RE). On the basis of dietary intakes from complementary foods in Latin America, a level of fortification of 250 µg RE per 100 g of daily ration would meet 80% of the vitamin A needs of nonbreastfed children and all the needs of breastfed children, and it would not exceed the upper limit set by the United States for intake by breastfed children consuming the recommended daily ration [38].

High-dose vitamin A supplementation is not relevant in considering fortification levels. At present,

the coverage of semiannual doses, which are necessary to keep vitamin A stores at an adequate level and to prevent subclinical deficiency, is not widely achieved. The risk of toxicity in the presence of both vitamin A supplementation and the recommended levels of fortification is negligible.

B vitamins. Because of a lack of quantitative data on which to base precise recommendations, the US recommended intakes of B vitamins for the target population are AIs, which, as noted earlier, are based on observed intakes. Also as previously mentioned, these have the potential to exceed the actual requirements. For infants aged 7 to 12 months, the AIs for thiamine and niacin were estimated by extrapolating down from the adult estimated average requirements (EARs) ± 2SD. In the case of biotin, the EARs were estimated by extrapolating upwards from the AI of infants aged zero to six months. For riboflavin, vitamin B_6, folate, vitamin B_{12}, pantothenic acid, and choline, the EARs were estimated by extrapolating upward from the AIs of infants aged zero to six months and downward from the adult EAR ± 2SD [39]. For young children aged 12 to 24 months, the recommendations for thiamine, riboflavin, niacin, vitamin B_6, and folate were estimated by extrapolating down from the adult EARs ± 2SD to derive the RDA. In the case of pantothenic acid, biotin, and choline, the recommended intakes are AIs because the adult recommendations are also AIs. The US recommendations are similar to those set in the United Kingdom, with the exception of a lower recommendation for folate in the United Kingdom. With the exception of niacin, folic acid, and choline, none of the vitamins has an upper limit of intake.

The recommended levels of fortification are calculated per 100 kcal and are set to cover the needs of the groups with the highest requirements (in this case, those not breastfeeding) (table 6) [39]. The recommendations also assume that the child will need to meet his or her requirement from this complementary food and that there is no risk of toxicity at any of the proposed levels.

Iodine. The International Council for the Control of Iodine Deficiency Disorders (ICCIDD) and WHO recommend a daily intake of 90 μg of iodine for infants and young children. This recommendation is similar to that of the US Food and Nutrition Board [40]. Despite worldwide efforts to fortify salt with iodine, pockets of deficiency continue to exist; however, at the same time, excess iodine intake has been documented in a number of countries in Latin America [41]. Iodine is not routinely added to fortified complementary foods, and Dunn has recommended the addition of 90 μg per daily ration to ensure an adequate intake for infants and young children [41].

Micronutrient interactions

Although micronutrient interactions among some of the minerals are possible, none of them is likely to be important at the concentrations suggested in the preceding section. There is a potential risk that fortification with mineral salts will reduce the bioavailability of other minerals in the food by either changing their intestinal solubility or competing for uptake at absorption sites [37]. However, data on such potential mineral–mineral interactions have come primarily from studies of single mineral dietary supplements, as opposed to the use of minerals as fortificants in foods [37].

Concern has primarily centered on the effect of fortification with calcium and phosphorus on iron and zinc absorption, the effect of fortification with zinc on copper absorption, and the effect of fortification with iron on zinc absorption. However, several studies have shown that neither iron absorption nor its status was affected when infants were fed calcium- and phosphorus-fortified formulas [42], or when children were fed a calcium-fortified breakfast cereal [43]. Data are not available to provide recommendations on the optimal dietary ratios of calcium to zinc [37]. Negative effects of typical zinc intakes on copper absorption have not been demonstrated [36]. However, the addition of conservative amounts of copper to zinc-fortified foods may

TABLE 6. Recommended amounts of B vitamins to be added to complementary foods (per 100 kcal)

Nutrient	Amount if no breastmilk, uncooked food		Codex Alimentarius	% increase for cooking loss	Amount for cooked food 6–24 mo
	6–12 mo	12–24 mo			
Thiamine (mg)	0.036	0.046	0.08	+80	0.08
Riboflavin (mg)	0.060	0.046	0.13	+75	1.05
Niacin (mg)	0.482	0.549	1.50	+75	0.96
Vitamin B_6 (mg)	0.036	0.046	0.15	+60	0.07
Folic acid (μg)	9.638	13.74	8.25	+90	26.11
Vitamin B_{12} (μg)	0.060	0.082	0.16	+10	0.09
Pantothenic acid (mg)	0.217	0.183	—	+50	0.32
Biotin (μg)	0.723	0.733	—	+60	1.17
Choline (mg)	18.07	18.32	—	+5	19.24

need to be considered. Fortification of foods with iron does not have a negative effect on zinc absorption [44]. The only exception to this finding was when the iron:zinc molar ratio was 25:1, a ratio that is highly unlikely to occur in fortified foods.

Additional macrolevel approaches

Sprinkles

Another potential macrolevel approach to improving micronutrient nutrition is to prepare packets of encapsulated micronutrients, each packet containing one daily ration, that are sprinkled onto food [45].* One of the main advantages of such sprinkles is that they can be produced and distributed at a far lower cost than complementary foods. Although such a packet is not commercially available, the cost of production in Canada and transport to Mongolia of a 0.5-g packet containing iron, vitamin C, vitamin A, vitamin D, zinc, and folic acid would be about US$0.03 (personal communication, Zlotkin S, Departments of Pediatrics and Nutritional Sciences, University of Toronto, Toronto, Canada, 2001). Calcium cannot be added to sprinkles because of its bulk and expense. The low energy density of the complementary foods that are often used is not addressed by this approach. However, energy density could be addressed by a complementary strategy to encourage the addition of fats or oils to local foods. At present, this strategy, although widely recommended, is not ideal because of the dilution of the micronutrients present [3].

The iron source in the sprinkles is ferrous fumarate, which is encapsulated in a soy lipid to ensure that it does not produce organoleptic changes when added to foods or cause rancidity during storage. This kind of encapsulated iron compound is widely used in baking, is relatively inexpensive, and is available from a large number of producers. The packet is a four-layer package consisting of paper-polyethylene-foil-polyethylene. This package has been shown to prevent gumming of the micronutrients in hot and humid climates [45].

Thus far, the effect of sprinkles has been evaluated only on iron status. Sprinkles were found to be as efficacious as iron drops among anemic young children aged 6 to 18 months over a two-month period [45]. An effectiveness study is under way in Mongolia with packets containing iron, zinc, vitamin C, vitamin A, vitamin D, and folic acid. Bioavailability studies using stable isotopes are also under way.

Overdosing is not likely to be a problem, since each packet contains no more than the RDA of each nutrient, and a child would have to consume multiple pack-

ets to receive toxic doses. The four-layer packaging is also a deterrent, since it makes the packets difficult to open. Also, data from the previously cited study show that parents did not use more than one packet per day and sometimes used less. Therefore, children might not be getting the required amounts of the nutrients if parents are trying to save the contents of the packets and make them last longer.

Although they still in the research and development stages, sprinkles could potentially play a role similar to that of oral rehydration salts, with distribution through both the public and the private sectors. Comprehensive social marketing campaigns would be required to convince the public and health professionals of their utility.

Fat-based spreads

A fat-based spread fortified with multiple micronutrients, has been developed as a ready-to-use food by the Institute of Research and Development in Paris and is commercially available. Originally developed for the rehabilitation of severely malnourished children, for which it is as effective as the standard WHO F100 diet [46], the concept has potential application to improve the energy and micronutrient density of complementary foods in nonemergency settings [47]. These products have the advantage of providing a food of high energy and nutrient density while being highly resistant to bacterial contamination [48]. They can be mixed with local complementary foods or eaten alone as a snack.

These products have a long shelf-life because all of the powdered ingredients are embedded in fat, which protects the micronutrients from oxidation. Because they contain no water and have a very low humidity, they are also naturally resistant to bacterial contamination [47]. They can therefore be used safely under poor hygienic conditions. The cost of the spreads depends on their macro- and micronutrient content. The micronutrient contents are usually cheaper than the fat, protein, and carbohydrate contents. Cost estimates suggest that spreads are less expensive than blended foods or locally available foods [49].

The spreads are made by mixing the dry powdered ingredients (dried milk products, precooked soy flour, sugars, dextrin maltose, minerals, and micronutrients) with vegetable fat. The spreads were originally made by replacing part of the dried skimmed milk in the WHO F100 product with dried lactoserum and peanut butter [48]. The advantages of peanut butter in some regions of the world are that it is inexpensive and locally available and has a high fat content, the right viscosity over a large range of temperatures, and an acceptable taste. The disadvantage is that it can provoke severe allergic reactions. This has not been a problem in the settings where the spread has been used, but it is of potential concern. Peanut butter could be substituted for differ-

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* Zlotkin S, Arthur P, Antwi Y, Schauer C, Yeung G. Randomized placebo-controlled trial of iron for short- and long-term prevention of anaemia in previously treated infants. Unpublished document.

ent sources of fat, but this is likely to increase the cost. In a field trial in Algeria, the dried milk products were replaced by precooked soy flour, which is considerably less expensive but is high in phytate, which impedes mineral absorption [50].

Although spreads are highly developed and are increasingly used to treat severe malnutrition in famine situations [51], additional research and development are needed for their application outside emergency settings. Very preliminary data suggest that spreads would be acceptable to young children and mothers (personal communication, Dewey K, Department of Nutrition, University of California, Davis, Calif., USA; personal communication, Lartey A, Department of Nutrition and Food Science, University of Ghana, Legon, Ghana, 2000). However, to date, no attempts have been made to develop a spread specifically designed for infants and young children aged 6 to 24 months [48]. A number of questions for this age group would have to be addressed: At what age can a child safely eat a spread as a snack? Is the absorption of iron impaired when it is surrounded by fat in the duodenum? What would be the optimum micronutrient content?

In order for products such as fortified complementary foods, sprinkles, and nutritionally sound formulations to have an impact beyond the population that participates in feeding programs, demand for the products and a distribution network have to be established in the commercial sector. Comprehensive social marketing campaigns are required to convince the public and health professionals of their utility.

Economic considerations*

Given the increase in urbanization and cash economy throughout the developing world, the commercial sector has a potential role to play in the marketing of fortified complementary foods. At present, the dominant products in many countries are those of Nestlé and Gerber, which are widely advertised, expensively packaged, and accessible to only a very small proportion of the population. These products sell at a price many times higher than the cost of a nutritionally similar product [18]. As mentioned earlier, although a number of public agencies have introduced low-cost fortified complementary foods, most have failed to achieve a sustained demand in the open market and have, therefore, failed as commercial endeavors. The one notable exception to these market failures is Incaparina, which, although developed by a public agency, is produced by a private company and is widely available at low cost.

Credence attributes and asymmetric information

One difficulty in achieving market demand for low-cost fortified complementary foods stems from the fact that nutritional density is what economists refer to as a "credence attribute" [52]. A credence attribute is a desired quality that is unobservable prior to use and also cannot be observed after use because of the many confounding factors that impede assessment of its effect. In the case of infant and young child nutrition, these factors include infections, parasites, and possibly prenatal programming because of small maternal size. Also important is the fact that neither micronutrient status nor growth can be readily observed. Because nutrient density is unobservable, a consumer must make purchases while trusting that the product contains what is on the label and will fulfill what is promised. Economists have noted that this kind of asymmetric information, unless corrected, reduces sales because consumers are unwilling to pay for any given product out of concern that an inferior one has been substituted [53] (cited by Masters and Sanogo [52]).* To sustain a commercial market for the product, the producer must build trust through brand identity and aggressive promotional campaigning or reliance on a third party to provide certification of the contents. Both solutions involve costs in communicating information.

Building trust on brand identity involves signaling quality by high prices [54] (cited by Masters and Sanogo [52]), conspicuous expenditure on packaging and advertising [55] (cited by Masters and Sanogo [52]), and a combination of both strategies [56] (cited by Masters and Sanogo [52]). These are very expensive to the consumer but provide assurance that the producers have an incentive to maintain quality.

Third-party certification

Voluntary third-party certification is used to create a separate market for information about product quality, which consumers can observe directly through a seal or some other identifying mark on a product. At the same time, it encourages producers to maintain quality at competitive prices [57] (cited by Masters and Sanogo [52]). Such a system is somewhat self-policing, since all producers who participate have the incentive that the products of their competitors are tested with the same standards of quality. Certification encourages producers to invest in a collective brand identity and to compete in the market by providing that "brand" at a lower cost or by offering some other attribute, such as improved packaging. Although the producer pays

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* This section draws heavily on the paper by Masters and Sanogo [52].

* Akerlof was awarded the Nobel Prize for Economics for this idea, and his 1970 paper on asymmetric information was cited when the award was given.

for the cost of certification, these costs are minimal and can be passed on to the consumer.

Certification has fixed costs and requires a minimum market size to be cost-effective and self-financing [58] (cited by Masters and Sanogo [52]). It is not likely to be attractive to well-established producers, who will prefer the high profits stemming from brand identity and their monopoly of the market. However, such producers might be induced to join a certification program and reduce their prices if, as a result of competition with the products of other companies, they see their market share and profits decline [59] (cited by Masters and Sanogo [52]).

Certification is already widely used for fortified complementary foods, but it is limited to large buyers who contract independently for laboratory testing. The World Food Program, which contracts a large share of its complementary food (blended food) production to manufacturers in developing countries, uses independently registered surveyors to test the products and to issue a Certificate of Fitness for Human Consumption [18]. A similar testing program is conducted for the complementary foods distributed through the USAID Title II program [60].

There are some examples of third-party certification of food and products purchased at the level of the household, although not yet for fortified complementary foods. In Chile, the Instituto de Nutrición y Tecnología de Alimentos (INTA) certifies the quality of salt iodation and communicates this information to the consumer by putting their seal on the top of each salt container. In Argentina, the Centro de Estudios Sobre Nutrición Infantil (CESNI), a well-known nutrition institute, has been involved in the development of a fortified bread product with a national company. CESNI has entered into an agreement with the producer to certify that the product meets the advertised fortification levels through twice-monthly, random quality control checks and, in exchange, will permit the use of its logo on the bread. The producer will pay CESNI for the testing, passing on the minimum cost to the consumer (personal communication, O'Donnell A, Centro Estudios sobre Nutrición Infantil, Buenos Aires, Argentina, 2001). Finally, even though INCAP does not directly evaluate the nutritional content of Incaparina, its success in the market may relate to its association with this widely known nutrition institute.

The introduction of a certification program requires concerted action by consumers or the government to document the demand for certification and initiate a credible program. A national or institutional authority needs to establish sampling and testing protocols, authorize a laboratory to collect fees for quality control testing, and authorize producers who meet the criteria to use a standard certification logo on the product package and at the point of sale [52]. As in the Chilean and Argentinean examples, it is best if the certifying

institution is well known to the consumer so as to generate confidence and willingness to pay for the quality assured by the certification seal. Potential problems of liability in the event that a certified product results in harm to the consumer can be avoided through careful legal contracts so that the certifying agency is ensuring only the content and level of micronutrients, macronutrients, or both.

It is important to note that a third-party certification system certifies only that the product contains what is on the label and does not certify the nutritional adequacy of the food. Nutritional adequacy is ensured by adherence to the Codex Alimentarius Standard for Processed Cereal-Based Foods for Infants and Children, which any product traded on the international market is mandated to comply with. To guarantee the minimal standard of nutritional quality mandated by the Codex, any third-party certification system for fortified complementary foods should insist that products comply with the Codex.

Mothers' willingness to pay

Limited data suggest that mothers, including those with little education and resources, are willing to pay for a product that contains a seal of certification [52]. An experimental trial in the capital of Mali showed that, on average, the premium that mothers were willing to pay for a seal of certification was an additional US$1.75 per kilogram of fortified complementary food. This amount is additional to other costs, which would be expected to vary with the ingredients, packaging, and location, and it represents approximately four times the estimated certification cost. Although higher-income and better-educated mothers were willing to pay more for certification, very poor and uneducated mothers were also willing to pay for certification in excess of the estimated costs of such a program. Furthermore, they were unwilling to pay for anonymous products of unknown quality [61]. This behavior is eminently rational. A recent analysis of a national complementary food in Uganda, Kenya, and Mali showed very irregular standards of quality, with a range of 6.5% to 12.9% in protein content and 2.6% to 5.6% in fat content (personal communication, Masters W, Department of Agricultural Economics, Purdue University, West Lafayette, Ind., USA, 2001). The trial also showed that less than one-tenth of the mothers' willingness to pay for the brand name of Nestlé cereals was for adequacy of the ingredients, one-third was for basic processing of the ingredients, one-third was for the quality of information provided by the label, and the rest was for other attributes, such as better processing, more durable packaging, and residual confidence above that provided by a certification agency [52].

The results suggest that the certification of a product would not eliminate the value of a product of a differ-

ent brand that is currently well known on the market, but it could have a significant impact on its profitability. More importantly, certification has the potential to develop a market for other nutritionally adequate and lower-cost products accessible to a broader range of consumers. Thus, it would facilitate the entry and expansion of new and small-scale producers. There may also be a demand for such certification from producers.

Policy considerations

Consumer protection

Given the infant morbidity and mortality that have resulted from the unethical and inappropriate marketing of breastmilk substitutes [2, 19, 21], the fact that many companies producing infant formulas also produce complementary foods, and the potential of such foods to compete with breastmilk and local foods, strong and enforceable consumer protection and consumer education are of critical importance. The principal international documents regulating the composition and marketing of complementary foods and thus providing the basis for consumer protection are the International Code of Marketing of Breast-Milk Substitutes [2], subsequent relevant World Health Assembly (WHA) resolutions, and the Codex Alimentarius Standards for Canned Baby Foods and for Processed Cereal-Based Foods for Infants and Children [62]. For the purposes of promoting fortified complementary foods that can potentially reach a large proportion of the population, the Codex Standard for Processed Cereal-Based Foods is more relevant than the Standard for Canned Baby Foods. Also relevant are the Guidelines on Formulated Supplementary Foods for Older Infants and Young Children, which are included in the 1991 revision of the Codex Standard for Processed Cereal-Based Foods for Infants and Children [63].

International Code of Marketing of Breast-Milk Substitutes

The International Code of Marketing of Breast-Milk Substitutes, adopted by the World Health Assembly in 1981 [2], with subsequent relevant World Health Assembly Resolutions, collectively known as the Code, provides guidelines for the marketing of breastmilk substitutes, bottles, and teats. Article 2 of the Code, which addresses the scope of the Code, states that "The Code applies to marketing, and practices related thereto, of the following products: breast-milk substitutes, including infant formula; other milk products, foods and beverages, including bottle-fed complementary foods, when marketed or otherwise represented to be suitable with or without modification, for use as a partial or total replacement of breast-milk, bottles and

teats." As such, the Code applies to complementary foods when they are represented as suitable for use as partial or total replacement for breastmilk. Article 3 of the Code defines a complementary food as "…any food, whether manufactured or locally prepared, suitable as a complement to breast-milk or to infant formula, when either becomes insufficient to satisfy the nutritional requirement of the infant." Inasmuch as the recommended duration of exclusive breastfeeding is six months (resolution WHA54.2) [64], complementary foods should not be promoted or marketed for infants below this age. Thereafter, foods should not be marketed in ways that promote their use as a substitute for breastfeeding. This was stressed by the World Health Assembly in 1996 (resolution WHA49.15) when it urged governments "to ensure that complementary foods are not marketed for or used in ways that undermine exclusive and sustained breastfeeding."

Codex Alimentarius

The Codex Alimentarius Commission was established in 1962 by the World Health Organization and the Food and Agriculture Organization (FAO) to carry out the Food Standards Program. The goal of this program is to protect the health of consumers and facilitate international trade in foods. The Codex Standard for Processed Cereal-Based Foods for Infants and Children was adopted in 1976 and amended in 1985, 1987, and 1991 [62]. It sets standards for the essential composition of such foods, including the kinds of cereals to be used, the content and quality of protein, and the sodium content. The section on Optional Ingredients proposes that the addition of vitamins and minerals should be in conformity with the legislation of the country in which the product is sold and, thus, does not provide specific standards to follow for micronutrient fortification. The Standard also provides guidelines on quality factors, consistency and particle size, food additives, contaminants, hygiene, packaging, labeling, and methods of analysis and sampling. It is currently undergoing further revisions, and a critical question is how the most recent resolution of the World Health Assembly regarding the recommended duration of exclusive breastfeeding will be reflected in these revisions.

The purpose of the Guidelines on Formulated Supplementary Foods for Older Infants and Young Children [63] is to provide guidance on the nutritional and technical aspects of the production of formulated supplementary foods for older infants and young children. These guidelines propose the following:

» An energy density of at least 400 kcal per 100 g of the food
» An amino acid score of not less than 70% of that of casein
» A fat content between 20% and 40%, corresponding to 10 to 25 g of fats or oils per 100 g of the food, with the level of linoleic acid not less than 300 mg per 100 kcal or 1.4 g per 100 g of product

The Guidelines further state that when a complementary food for older infants and young children is supplemented with one or more nutrients, the total amount of the added vitamins and minerals should be at least two-thirds of the reference daily requirements per 100 g of the food on a dry matter basis. However, they also state that this information is "simply a guideline to emphasize the nutrients to be considered in the development of a supplementary food" (p. 60) and that "appropriate modifications might have to be made for adapting them to specific conditions" (p. 57) [63].

The Codex Standard for Processed Cereal-Based Foods for Infants and Children needs to be improved and updated. The Guidelines suggest a consumption of 100 g per day (about 400 kcal), even for infants. This is an extremely large amount, given that the estimates of energy needed from complementary foods for infants receiving an average amount of breastmilk are only 200 kcal for infants aged 6 to 8 months and 300 kcal for those aged 9 to 11 months [4]. Also, data from Ghana, Mexico, and Peru show that infants consume far less than this amount. Therefore, even if the guidelines for nutrient fortification were followed, inasmuch as infants are likely to consume less than 100 g per day of the complementary food, they would receive far less than two-thirds of their vitamin and mineral requirements.

Improving the policy environment

Measures can be adopted to provide incentives or eliminate disincentives for the development and marketing of fortified complementary foods. In Argentina, the tax on milk fortified with nutrients other than vitamins A and D was more than 20% higher than the tax on minimally fortified milk. As part of an initiative to fortify the milk used in the national maternal and child health programs with iron and zinc, the law was changed and the tax was removed. Since the new law also applies to milk not distributed through the maternal and child health program, milk fortified with iron and zinc in addition to vitamins A and D can now compete in the market with milk fortified with only vitamins A and D.

Potential challenges

A major challenge in promoting fortified complementary foods is to ensure that such foods are promoted in a way that does not confuse a promotional message with one that creates a reliance on any particular commercially produced product or that undermines breastfeeding or the use of local foods. Ideally, fortified complementary foods would be promoted within the context of enforceable Code legislation. In some countries, the National Breastfeeding Committee or other entity reviews all labels of formulas and infant foods to ensure that they include messages about the importance of breastfeeding. Ideally, this would be part of enforceable Code legislation or, at a minimum, a mandate of the relevant government infant feeding committees. It is also important for such a review to ensure that information about the importance of local foods in the diet of young children is also included. For example, in Ecuador the package of a fortified complementary food distributed as part of a national strategy to improve infant and young child nutrition includes messages about the importance of breastfeeding and dietary variety. To avoid giving consumers the idea that other foods were not also necessary, the words "a complete nutritional food" were not included on the package.

Another major challenge is the monitoring of quality control. Funding for ongoing quality control and assurance measures is often inadequate and has been an ongoing problem with other fortification strategies. For example, in Latin America only 5 countries have adequate monitoring programs for iodized salt, and 10 have partial monitoring [41]. A system to ensure the nutritional quality of the products would be needed, possibly through a third-party certification system, as described above.

Recommendations for action

Global level

1. Support active participation and involvement of developing countries in relevant Codex committees. With increased globalization and enforcement of the Codex by the World Trade Organization, it is becoming increasingly important in the commercial sector. Active participation of developing countries in the development of the Codex standards relevant to infant and young child nutrition is critical to ensure that the best interests of young children (the vast majority from developing countries) are served.
2. Support technical consultations to inform relevant Codex committees of the nutritional requirements for fortified complementary foods. For example, a daily ration size of 100 g is far too high. Guidelines should also specify mineral compounds that should be used, particularly with respect to iron, since bioavailabilities and cost vary markedly.
3. Support implementation and monitoring of the International Code of Marketing of Breast-Milk Substitutes. The promotion of fortified complementary foods in the commercial sector should only exist in the context of enforceable Code legislation.
4. Develop protocols for quality assurance testing of fortified complementary foods.
5. Convene a meeting to review experiences with third-party certification systems and to analyze legal and

party certification systems and to analyze legal and other implications. Develop a model protocol for a quality certification system. Advocate for the development of such systems in developing countries.

6. Support efficacy and effectiveness research on fortified complementary foods, sprinkles, and spreads to determine the optimal level of fortification and the amounts consumed per day and per serving by age group (6 to 8, 9 to 11, and 12 to 23 months).

7. Support the analysis of the bioavailability of iron and zinc in the fortified foods currently used in feeding programs and available in the commercial market.

National level

1. Carry out implementation, monitoring, and enforcement of the International Code of Marketing of Breast-Milk Substitutes.
2. Participate in the relevant Codex committees.

3. Identify research centers or independent laboratories that could serve as possible sites for a third-party certification system.
4. Contemplate the possibility of setting up a regional monitoring, evaluating, and certifying system for fortified complementary foods.

Acknowledgments

References

1. World Health Organization. The WHO/UNICEF Joint Meeting on Infant and Young Child Feeding. Geneva: WHO, 1979.
2. World Health Organization. The international code of marketing of breast-milk substitutes. Geneva: WHO, 1981.
3. World Health Organization. Complementary feeding of young children in developing countries: a review of current scientific knowledge. WHO/NUT/98.1. Geneva: WHO, 1998.
4. Dewey KG, Brown KH. Nutrient composition of fortified complementary foods: Should age-specific micronutrient content and ration sizes be recommended? J Nutr 2002 (suppl), 2003.
5. WHO/UNICEF. Global strategy for infant and young child feeding 2002. Document A55/15. Geneva: World Health Organization, 2002.
6. Lutter CK. Processed complementary foods: summary of nutritional characteristics, methods of production and distribution, and costs. Food Nutr Bull 2000;21:95–100.
7. Horton S. Cost analysis of feeding and food subsidy programmes. Food Pol 1993(June):192–9.
8. Musgrove P. Feeding Latin America's children. World Bank Research Observer 1993;8:23–45.
9. López de Romaña G. Experience with complementary feeding in the FONCODES project. Food Nutr Bull 2000;21:43–8.
10. Hertramph E, Olivares M, Pizarro F, Walter T. Iron fortification in the Americas. Nutr Rev;60(7 Part II):S22–5.
11. Dewey KG. Approaches for improving complementary feeding of infants and young children. Geneva: World Health Organization, 2000.
12. Ruel MT. Urbanisation in Latin America: constraints and opportunities for child feeding and care. Food Nutr Bull 2000;21:12–24.
13. Maxwell D, Levin C, Armar-Klemesu M, Ruel M, Morris S, Ahiadeke C. Urban livelihoods, food and nutrition

security in greater Accra. IFPRI Research Report No. 112. Washington, DC: International Food Policy Research Institute, April 2000.
14. Tartanac F. Incaparina and other Incaparina-based foods: experience of INCAP in Central America. Food Nutr Bull 2000;21:49–54.
15. Barenbaum M, Pachón H, Schroeder DG, Hurtado E. Use, acceptability, and cost of Incaparina, a commercially processed food, in Guatemala. Food Nutr Bull 2001;22:71–80.
16. Mora J. The need for a market-oriented approach. Food Nutr Bull 2000;21:83–5.
17. Zafer I. Social marketing of processed foods. Food Nutr Bull 2000;21:91–4.
18. Dijkhuizen P. Processed complementary foods in the World Food Programme. Food Nutr Bull 2000;21:62–4.
19. Taylor A. Violations of the international code of marketing of breast-milk substitutes: prevalence in four countries. BMJ 1998;316:1117–22.
20. Association for Rational Use of Medication in Pakistan. Feeding fiasco: pushing commercial foods in Pakistan. Islamabad: Network Publications Services, 1998.
21. IBFAN. Breaking the rules: stretching the rules. Penang, Malaysia: International Baby Food Action Network, 2001.
22. Butte NF, Wong WW, Hopkinson JM, Heinz CJ, Mehta NR, Smith EOB. Energy requirements derived from total energy expenditure and energy deposition during the first 2 years of life. Am J Clin Nutr 2000;72:1558–69.
23. Dary O. Staple food fortification with iron: a multifactorial decision. Nutr Rev 2002:60(7 Part II):S30–3.
24. Rivera J, Rodríguez G, Shamah T, Rosado JL, Casanueva E, Maulén I, Toussaint G, García-Aranda A. Implementation, monitoring, and evaluation of the nutrition component of the Mexican Social Programme (PROGRESA). Food Nutr Bull 2000;21:35–42.

25. Institute of Medicine, Food and Nutrition Board. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D and fluoride. Washington, DC: National Academy Press, 1997.
26. Institute of Medicine. Dietary reference intakes for thiamine, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, pantothenic acid, biotin, and choline. Washington, DC: National Academy Press, 1998.
27. Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academy Press, 2000.
28. Institute of Medicine. Dietary reference intakes: applications in dietary assessment. Washington, DC: National Academy Press, 2000.
29. United Kingdom Department of Health. Report on health and social subjects. Dietary reference values for food and energy and nutrients for the United Kingdom. London: Her Majesty's Stationery Office, 1991.
30. FAO/WHO/UNU. Energy and protein requirements. WHO Technical Report Series No. 724. Geneva: World Health Organization, 1985.
31. 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 2002;24:5–28.
32. World Health Organization. Iron deficiency anaemia: assessment, prevention, and control. (WHO/NID/01.3). Geneva: WHO, 2001.
33. Dewey KG. Nutrition, growth, and complementary feeding of the breastfed infant. Pediatr Clin North Am 2001;48:87–104.
34. Hurrell R. Influence of vegetable protein sources on trace element and mineral bioavailability. J Nutr 2002 (suppl), 2003.
35. Lynch S. Iron and ascorbic acid: proposed fortification levels and recommended iron compound. J Nutr 2002 (suppl), 2003.
36. Rosado JL. Zinc and copper: proposed fortification levels and recommended zinc compounds. J Nutr 2002 (suppl), 2003.
37. Abrams SA, Atkinson SA. Calcium, magnesium, phosphorus and vitamin D fortification of weaning foods. J Nutr 2002 (suppl), 2003.
38. Mora J. Proposed vitamin A fortification levels. J Nutr 2002 (suppl), 2003.
39. Allen L. B vitamins: proposed fortification levels for complementary foods for young children. J Nutr 2002 (suppl), 2003.
40. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press, 2001.
41. Dunn J. Iodine should be routinely added to complementary foods. J Nutr 2002 (suppl), 2003.
42. Dalton MA, Sarget JD, O'Connor GT, Olmstead EM, Klein RZ. Calcium and phosphorus supplementation of iron-fortified infant formula: no effect on iron status of healthy full-term infants. Am J Clin Nutr 1997;65:921–6.
43. Abrams SA, Griffin IJ, Davila P, Liang L. Calcium fortification of breakfast cereal enhances calcium absorption in children without affecting iron absorption. J Pediatr 2001;139:522–6.
44. Whittaker P. Iron and zinc interactions in humans. Am J Clin Nutr 1998;68(S):442–4.
45. Zlotkin S, Arthur P, Antwi KY, Yeung G. Treatment of anemia with microencapsulated ferrous fumarate plus ascorbic acid supplied as "sprinkles" added to complementary (weaning) foods. Am J Clin Nutr 2001;74:791–5.
46. Briend A, Lacsala R, Prudhon C, Mounier B, Grellety Y, Golden MH. Ready-to-use therapeutic food for treatment of marasmus. Lancet 1999;353:1767–8.
47. Briend A. Highly nutrient-dense spreads: a new approach to deliver multiple micronutrients to high-risk groups. Br J Nutr 2001;85(suppl 2):2175–9.
48. Briend A. Possible use of spreads as a FOODlet for improving the diets of infants and young children. Food Nutr Bull 2002;23:239–43.
49. Briend A, Ferguson E, Darmon N. Local food price analysis by linear programming: a new approach to assess the economic value of fortified food supplements. Food Nutr Bull 2001;22:184–9.
50. Branca F, Lopriore C, Guidoum Y, Briend A, Golden MH. Multi-micronutrient fortified food reverses growth failure and anaemia in 2–5-year-old stunted refugee children. Scand J Nutr 1999;43:51S (abstract).
51. Collins S. Changing the way we address severe malnutrition during famine. Lancet 2001;358:498–501.
52. Masters WA, Sanogo D. Welfare gains from quality certification of infant foods: results from a market experiment in Mali. Am J Agric Econ 2002;84:in press.
53. Akerlof GA. The market for "lemons": quality uncertainty and the market mechanism. Q J Econ 1970;84:488–500.
54. Wolinsky A. Prices as signals of product quality. Rev Econ Studies 1983;50(October):647–58.
55. Nichols MW. Advertising and quality in the U.S. market for automobiles. Southern Econ J 1998;64:922–39.
56. Milgrom PRD, Roberts JM. Price and advertising signals of product quality. J Political Econ 1986;94(August):796–821.
57. Caswell JA, Padberg DI. Toward a more comprehensive theory of food labels. Am J Agric Econ 1992;74:460–8.
58. Auriol E, Schillizi S. Quality signaling through certification. Theory and an application to agricultural seed markets. Toulouse, France: L'Institut d'Economie Industrielle. www.idei.asso.fr
59. Crespi JM, Marette S. How should food safety be financed? Rennes, France: Institut National de la Recherche Agronomique, Département d'Economie et Sociologie (INRA-ESR), 2000.
60. Marchione T. Title II food aid and the nutrition of children in Latin America and the Caribbean. Food Nutr Bull 2000;21:65–72.
61. Sanogo D, Masters WA. A market-based intervention to improve child nutrition: mothers' demand for quality certification of infant foods in Bamako, Mali. Food Pol 2002;27:251–68.
62. Clark D, Shrimpton R. Complementary feeding, the Code, and the Codex. Food Nutr Bull 2000;21:25–9.
63. WHO/FAO. Codex standard for processed cereal-based foods (including guidelines on formulated supplementary foods for older infants and young children). Geneva: World Health Organization, 1991.
64. World Health Assembly. Resolution WHA54.2: Infant and young child nutrition. Geneva: World Health Organization, 2001.

Household-level technologies to improve the availability and preparation of adequate and safe complementary foods

Patience Mensah and Andrew Tomkins

Abstract

Plant-based complementary foods are the main source of nutrients for many young children in developing countries. They may, however, present problems in providing nutritionally adequate and safe diets for older infants and young children. The high starch content leads to low-nutrient diets that are bulky and dense, with high levels of antinutritive factors such as phytates, tannins, lectins, and enzyme inhibitors. Phytates impair mineral bioavailability, lectins interfere with intestinal structure, and enzyme inhibitors inhibit digestive enzymes. In addition, there is often microbial contamination, which leads to diarrhea, growth-faltering, and impaired development, and the presence of chemical contaminants may lead to neurological disease and goiter. The fact that some fruits containing carotenoids are only available seasonally contributes to the vulnerability of children receiving predominantly plant-based diets. Traditional household food technologies have been used for centuries to improve the quality and safety of complementary foods. These include dehulling, peeling, soaking, germination, fermentation, and drying. While modern communities tend to reject these technologies in favor of more convenient fast-food preparations, there is now a resurgence of interest in older technologies as a possible means of improving the quality and safety of complementary foods when the basic diet cannot be changed for economic reasons. This paper describes the biology, safety, practicability, and acceptability of these traditional processes at the household or community level, as well as the gaps in research, so that more effective policies and programs can be implemented to improve the quality and safety of complementary foods.

Key words: Complementary foods, household food processing, antinutritive factors, food safety, fermentation, germination/malting, enrichment

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Introduction

In a World Health Assembly Resolution (WHA54.2) in 2001, the World Health Organization recommended that infants should be exclusively breastfed for the first six months of their life. From six months up to two years or older, they should receive complementary foods together with continued breastfeeding. Achieving a diet that is nutritionally adequate and safe is difficult among 6- to 24-month-old children who have a predominantly plant-based diet. There are several important challenges that carers have to overcome in order to provide safe and nutritious foods. Many complementary diets are mainly based on plants, cereals, or roots, and the large amounts of starches in these plant sources result in a thick, gelatinous porridge, which often has a low nutrient content. In addition, mineral bioavailability is poor in many plant-based foods.

This paper reviews some of the problems facing carers as they choose and prepare foods that aim to satisfy the nutritional requirements of infants and young children for growth, development, immunity, and health. It also examines some of the food technologies that can be used to improve the nutritional content and safety of complementary diets.

Most plant foods based on cereals and legumes contain high levels of phytates, which interfere with the bioavailability of micronutrients such as iron, zinc, and calcium. For example, the mean phytate:zinc molar ratios of unrefined maize and soy flour are around 30, as compared with the recommended ratio of 15 [1]. Many plant-based foods have antinutritive factors such as tannins and lectins, which impair the absorption or bioavailability of nutrients and may damage the intestinal mucosa. In addition, many plants contain inhibitors of digestive enzymes. Microbial contamination of these foods is common and contributes to high rates of diarrheal disease, growth-faltering, and death. Particular problems exist in situations where the food is stored for some hours after preparation. Chemical toxins also occur, e.g., aflatoxin is an important cofactor with hepatitis B in the development of primary liver cancer. Cyanogenic glycosides can produce severe

tropical ataxic neuropathy and contribute to the development of goiter in areas where the iodine intake is marginal.

The seasonal availability of nutritious foods, particularly those containing carotenoids, means that without the application of food storage technology, children are deprived of important sources of antioxidants for many months of the year. The period of complementary feeding, when breastmilk alone is no longer sufficient to meet the nutritional needs of infants, is a potentially hazardous one, both nutritionally and microbiologically. Household and community technologies can therefore help to improve the quality of complementary foods and feeding.

Over the years a variety of food technologies have been developed globally by carers who, without biochemical knowledge of food processing, discovered that certain food preparation and cooking activities improved the quality and safety of complementary foods. Many of these traditional technologies are carried out by female family members who spend a considerable amount of their time in food preparation. Despite the extra burden and labor involved,

these processes appear to have been used for centuries. However, there is much anecdotal evidence that these food technologies are less popular now than they were in past decades [2]. The precise reasons are unknown, but a general preference for modern and fast foods may be responsible.

While inadequate and unsafe complementary foods compromise the health and development of children, it has been recognized recently that traditional household food technologies, often called microlevel technologies, are vital. In a more just world, the proportion of nutrients from animal products, as opposed to plant-based products, would be increased, thus improving the nutritional quality and bioavailability of complementary feeds. However, because this is impractical for the millions in poor countries, this review focuses on specific technologies that will improve the quality and safety of mainly plant-based complementary diets. Macrolevel approaches for improving complementary feeding practices are discussed elsewhere [3]. Figure 1 is a conceptual framework linking household food preparation technologies for the production of safe and nutritious complementary foods.
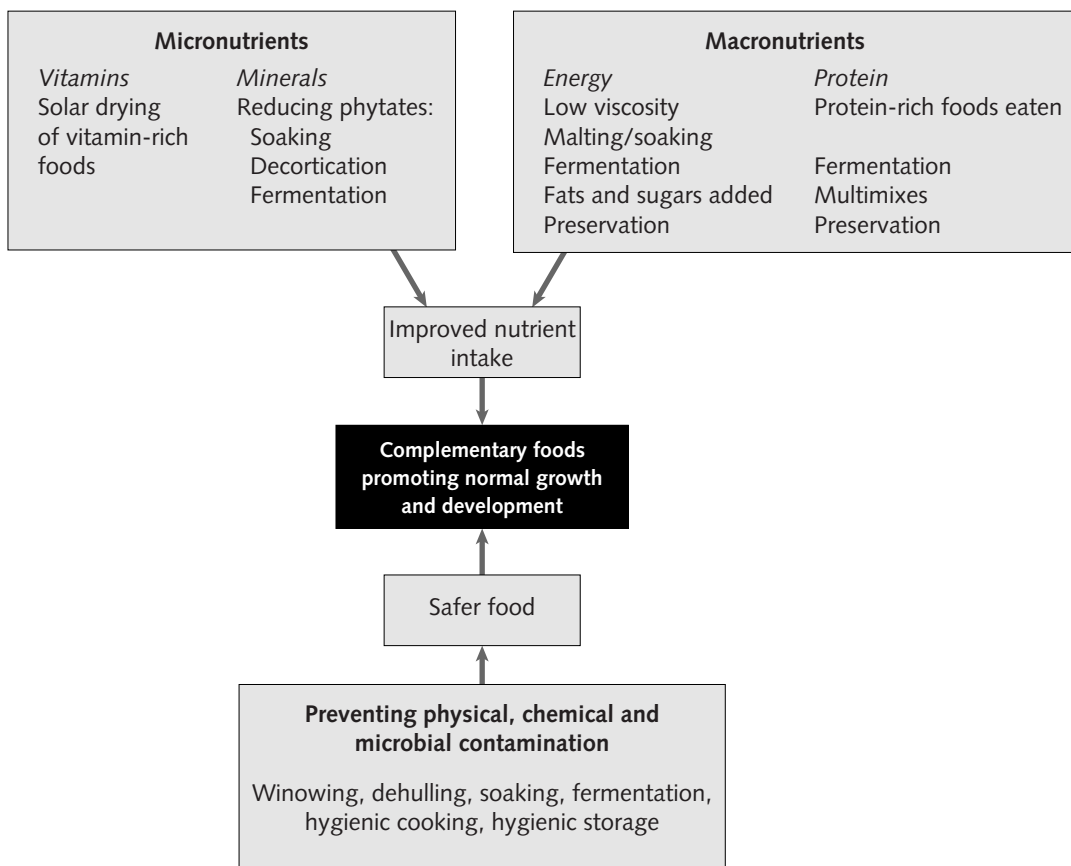

FIG. 1. Conceptual framework linking household food technologies for safe complementary foods and improving their nutrient content

Household food preparation technologies for improving the bioavailability of nutrients and the safety of complementary foods

Various technologies that are available for food preparation at the household level and the benefits from their use are profiled in tables 1 and 2. The main features of the following processes are described below: dehulling and peeling, dry roasting or toasting, smoking, drying, soaking, fermentation, germination/malting, enrichment by the addition of specific nutrients to the food, and the use of vacuum flasks for storage of prepared foods.

Dehulling and peeling

Biology

Dehulling removes the fibrous outer layers of grains. The grain is mixed with about 10% water or allowed to soak overnight, then pounded and winnowed, a process that is laborious, time-consuming, and inefficient. A woman will usually manage to decorticate 1.5 kg of grain in an hour of extremely hard work [4], which is enough for a small family. Mechanized processing is available for dehulling, but not all villages have access to this equipment. Peeling is usually carried out manually. However, simple, time-saving equipment exists that is suitable for cottage industries.

The removal of unwanted parts by peeling and dehulling reduces the levels of poisonous glycosides in root tubers, such as cassava and germinated sorghum [5, 6]. The effect of dehulling on the levels of starch, protein, phytic acid, and polyphenols in standard and Ugandi cultivars (cultivated varieties) of pearl millet has been evaluated [6]. Table 3 shows that phytic acid was reduced by about a half in the standard cultivar and by about a quarter in the Ugandi cultivar. Polyphenols were also reduced [7]. These reductions in antinutrients will improve the bioavailability of minerals. Thus, dehulling is a viable means of improving the nutritional quality of millet, sorghum, and other cereals that have antinutritive factors in the seed coat [8].

Safety

The traditional method of mixing with 10% water before pounding the grain results in a damp flour that could allow the growth of bacteria and fungi, and hence the production of aflatoxins.

Acceptability

Dehulling is normal practice in many communities.

Constraints

Manual dehulling is time-consuming and inefficient, requiring extra hard work for the women who are already burdened with other household chores.

Research needs

Research on the development of locally suitable methods of mechanized dehulling is needed.

Dry roasting or toasting

Biology

Roasting is a high-temperature, hydrothermal process that reduces the level of protease inhibitors and volatile glycosides. It improves the keeping qualities of the staple and adds flavor to bland products. Dry roasting reduces protein solubility and destroys a number of vitamins. The viscosity of the porridge made after roasting is reduced because of the dextrinization that occurs at high temperatures. In practice, roasting and the addition of amylase-rich flour are often used together to reduce the viscosity.

Safety

Roasting improves the shelf-life by reducing microbial contamination and by dehydrating the product.

Recent concerns about peanut allergy have resulted in avoidance of their use in the international travel industry (e.g., many airlines no longer serve peanuts), and there are health warnings on commercially prepared food items [9]. Peanut allergy has been described frequently in the past decade [10]. Studies in the United Kingdom [11] and the United States [12, 13] indicate

TABLE 1. Benefits of household food-processing technologies[a]

Benefit	Dehulling	Decortication	Roasting	Soaking	Malting	Fermentation
Organoleptic properties	–	+	+++	+++	++	+++
Detoxification	–	+++	–	+++	–	+++
Energy density	–	+	+	++	+++	+++
Viscosity	–	+	+	++	+++	++
Nutritive value	–	–	+	++	+++	+++
Acceptability	++	++	++	++	+++	+++
Stability	–	–	+++	–	–	+++
Safety	++	+++	++	–	–	+++

a. –, No benefit; +, below average; ++, average; +++, above average.

that the prevalence of peanut allergy is around 0.5% to 6% in apparently healthy children. Allergy to peanuts appears to start early in life and persists into adulthood [14, 15].

Allergy to soy appears to be less common than peanut allergy [13]. Roasted peanuts appear to be more allergenic than raw peanuts, which is attributed to increased levels of protein-bound allergens produced in the roasting process [16]. Frying and boiling rather than roasting may reduce the allergenicity of peanuts; this may account for differences in the rates of allergy between the United States and China [17]. The prevalence of allergies to peanuts and other nuts in the developing world is not known.

Acceptability

Roasting is widely practiced in many communities.

Constraints

Fuel availability is often a major constraint.

Research needs

There is a need for evaluation of the prevalence of peanut allergy in infants fed complementary foods

TABLE 2. Effect of household food technologies on antinutritive factors

Food technology	Staple	Antinutritive factor	% reduction	Country	Reference
Dehulling	Millet	Tannins	90	India	7
	Pearl millet	Polyphenols	22.4–26.4	Sudan	6
		Phytic acid	43.9–49.8		
Soaking	Sorghum SDS 2583 (tannin-free variety)	Phytic acid	48.5	Botswana	34
	Sorghum NK 3860 (high-tannin variety)	Phytic acid	7.1	Botswana	34
	Maize	Phytate	5.9	Ghana	25
	Maize	Phytate	2.2	Malawi	25
	Maize flour	Phytate	57	Malawi	28
	Pounded maize	Phytate	51	Malawi	28
Pressing of soaked pulp	Cassava	HCN	Reduced	Nigeria	58
Fermentation	Maize dough	Phytate	16.9	Ghana	25
	Maize dough	Phytate	2.7	Malawi	25
	Sorghum NK 3860 (dry-milled)	Phytate	26.7	Botswana	34
	Sorghum NK 3860 (wet-milled)	Phytate	34.7	Botswana	34
	Sorghum SDS 2583 (dry-milled)	Phytate	47.8	Botswana	34
	Sorghum SDA 2583 (wet-milled)	Phytate	43.3	Botswana	34
	Pearl millet	Phytate	27.1	India	7
	Dawadawa	Oxalate	43	Nigeria	58
	Cassava	HCN	30	Nigeria	58
Natural lactic fermentation	Maize flour	Phytate	12	Malawi	28
Natural lactic fermentation with germinated flour	Maize flour	Phytate	29	Malawi	28
Fermentation with starter	Maize flour	Phytate	39	Malawi	28
Natural lactic fermentation	Pearl millet flour	Polyphenols	31.1–59.9	Sudan	6
		Phytic acid	46.1–59.7		
Fermented porridge (10% dry matter)	With germinated maize flour	Phytate	46	Malawi	27
	With germinated millet flour	Phytate	43	Malawi	
Unfermented porridge	With germinated sorghum flour	Phytate	15	Malawi	27
	With germinated millet flour	Phytate	19	Malawi	
Soaking, fermentation, heating	Cooked cereal and legume (dosa)	Trypsin inhibitor	57.87	India	33

TABLE 3. Effect of dehulling on protein, starch, polyphenols, phytic acid, and in vitro protein digestibility of two cultivars (Standard and Ugandi) of pearl millet

Analysis	Standard whole	Standard dehulled	% change	Ugandi whole	Ugandi dehulled	% change
Starch (%)	66.9 (0.17)^a	71.6 (0.05)^a	+7.0	68.5 (0.15)^a	73.4 (0.30)^a	+7.2
Protein (%)	17.5 (0.17)^a	15.3 (0.25)^c	−12.6	16.3 (0.17)^b	15.1 (0.15)^c	−7.7
Total polyphenols (mg/100g)	303 (0.01)^c	235 (0.02)^d	−22.4	444 (0.02)^a	326 (0.02)^b	−26.4
Phytic acid (mg/100g)	943 (0.01)^b	473 (0.13)^c	−49.8	1,076 (0.16)^a	473 (0.3)^d	−43.9
IVPD (%)	72.7 (0.15)^c	79.1 (0.30)^a	+8.8	70.4 (0.25)^d	78.6 (0.15)^b	+11.6

Values are means ± SD. Means sharing a common letter (a, b, c, or d as superscripts) in a row are significantly different at $p \leq .05$ by Duncan's multiple range test.
IVPD, In vitro protein digestibility.
Adapted from ref. 6.

containing peanut butter or spreads, as well as evaluation of the effect of different cooking methods on the allergenicity of peanuts.

Smoking

Biology

Smoking is used to preserve fish in many communities. A variety of fuel-based ovens have been introduced, but most are unsatisfactory because of limitations on the amount of fish smoked at any one time, as well as environmental concerns and the labor-intensive nature of the process. Improved equipment for fish-smoking has been developed by the Food Research Institute in Ghana [18]. The Chorkor Smoker allows 10 trays of fish to be smoked at a time, which significantly improves fuel efficiency and the quality of the smoked fish. Different sizes of mesh allow fish of different sizes to be smoked. The Chorkor Smoker or its equivalent is used widely in western, central, and eastern Africa and in some parts of Asia.

Safety

Fish is a highly perishable food that begins to decompose and spoil shortly after harvesting. Autolysis causes an undesirable texture and flavor. Known contaminants are pathogenic bacteria and their toxins, as well as parasites; *Clostridium botulinum* is a bacterium of particular concern. Satisfactory food hygiene procedures and an adequate temperature for smoking are therefore essential.

Natural toxins, such as ciguara and scombroid (histamine) toxin, may be present in fish. Ciguara toxin is derived from the consumption of benthic dinoflagellates, *Gambierdiscus toxicus.* Scombroid poisoning is caused by ingestion of fish containing high levels of histamine, which is produced by enteric bacteria if cold storage is not adequate.

Members of the Scrombridae (tuna and mackerel) and other fish families commonly cause scombroid poisoning. Shellfish can also cause paralytic poisoning. These groups of sea fish may not be suitable for complementary foods.

Studies on *Sardinella* sp. and anchovies smoked and stored by traditional methods showed that these products were microbiologically safe when stored for up to six months. An integrated quality assurance system has been prepared by Plahar et al. [19].

Acceptability

Fish-smoking is practiced in many fishing communities, and the new fish smoker has been adopted in many African and some Asian countries.

Constraints

The main constraints are difficulties in fuel availability and seasonal availability of fish.

Research needs

The impact of smoking on the toxins in fish needs to be assessed.

Drying

Biology

Food preservation by drying is commonly practiced in tropical countries to ensure the stability and quality of the product during storage and its availability all through the year. Traditional sun-drying, although cheap, is associated with a number of problems, such as poor quality of the product; lack of control over the drying process; possible contamination by dirt, animals, and rodents; infestation with insects and mold if the food is dried slowly; and exposure to rain and wind, causing repeated wetting and drying.

To overcome these problems, new solar driers in which the product is dried in an enclosed chamber have been developed. Cereals, legumes, root tubers, and fish are traditionally dried for long-term storage (many months or even years). The use of solar driers for drying novel foods such as mangoes, carrots, orange-fleshed sweet potatoes, pumpkins, green leaves, and tomatoes is known to improve their availability.

In the United Republic of Tanzania, affordable solar driers constructed from local materials were tested in a study aimed at improving the consumption of dried,

high-β-carotene, green leafy vegetables. A total of 250 households with children around the ages of 12 to 71 months and a control group of 150 households took part in the study. Adoption of the drier by the women who participated in the study was high (77%). The Helen Keller International food-frequency scores, before and after the use of the drier, for assessment of vitamin A intake showed a 2.5-fold increase [20]. The high rate of adoption of the new technology was reported to be due to the involvement of mothers in the design and implementation of the programs from the start.

A participatory intervention study in Kenya introduced dried, orange-fleshed sweet potatoes to 10 communities [21]. In addition to the farming of sweet potatoes and other provitamin A–rich products, the five intervention groups of women received nutrition counseling. The children in the intervention groups consumed about 93% more vitamin A–rich foods, especially orange-fleshed sweet potatoes, mangoes, dark-green leafy vegetables, butter, and eggs, as compared with the controls.

Solomons and Bulux [22] described direct sun-drying and novel approaches where plastic sheets are used at high temperatures, preventing the deleterious effect of the sun's rays. The advantages of solar drying, as compared with direct drying, for the retention of provitamin A carotenoids are not yet clear. Carrots, spinach, papaya, parsley leaves, mangoes, pumpkins, and amaranth leaves, preserved using solar drying and sun-drying in Haiti and the Dominican Republic, showed a 50% or greater reduction of provitamin A carotenoids. Despite these findings, the dried foods still had sufficient provitamin A carotenoids. The Tanzanian study reported 1.6 times higher β-carotene in solar-dried green leafy vegetables than in those dried in the open air [20]. Consumption of this dried seasonal produce can contribute to higher micronutrient intakes throughout the year.

Safety

Suboptimal drying could create conditions for the growth of pathogenic bacteria and fungi and the production of toxins.

Acceptability

Sun-drying is used in the preservation of fish and other produce. The new solar drier has been successfully introduced in Tanzania.

Constraints

There are an insufficient number of locally produced solar driers, and poor harvests could affect the availability of food products.

Research needs

The efficacy of solar drying for other locally available foods and their nutritional quality after processing needs to be assessed, and the benefits of solar drying on individual carotenoid levels need to be quantified.

Soaking

Biology

Whole grains or flour may be soaked for up to 48 hours. The reported changes that occur after soaking whole grain are summarized in tables 1 and 2. There is a net enhancement of the protein solubility index. The bioavailability of amino acids (especially lysine, niacin, and thiamine) in edible grains is reported to increase by as much as 50% in some cases [23]. Little change was shown in the proximate composition of whole grains after they were soaked for 48 hours [24]. The level of phytates was reduced by 16.9% after whole maize grains were soaked [25]. Magnesium, calcium, and zinc salts of phytic acid are more soluble at lower pH values and insoluble at high pH values [26]. In West Africa, soaking of maize grains for many hours reduced the pH of the grains to around 5.0 and could account for the reported reduction in phytate.

The effects of soaking flour on phytate content, phytate:zinc molar ratio, and selected mineral and vitamin concentrations were evaluated [27, 28]. Soaked maize flour was prepared by soaking one part flour in four parts of water for 24 hours. The same quantities of water and pounded maize were held for one hour to make soaked pounded maize. The results show that soaking maize flour resulted in a 57% reduction and soaking pounded maize resulted in a 51% reduction in phytate (milligrams of inositol hexaphosphate, IP_6 + milligrams of inositol pentaphosphate, IP_5 per 100 g) (table 4). The greatest loss of phytate occurred during the first hour in a time-monitored study, and there was little change after 24 hours. About 80% of the phytates in maize are in the form of soluble salts such as sodium, potassium, or magnesium [29]. Simple diffusion and not phytase activity could be the mechanism for the reduction in phytates. Nevertheless, after the flour was soaked for one hour, the IP_5 + IP_6 content increased by 10%, which is suggestive of enzyme activity.

This simple method of soaking was tested in community trials and showed a moderate reduction of the phytate:zinc molar ratio in soaked pounded maize prepared by the mothers. The technology appeared to be acceptable to the mothers [27].

Soaking of finger millet and kidney beans did not significantly affect the extractability of calcium, iron, and zinc [30, 31], although high rates of extraction of phytates (more than 99%) were observed in bean flour [32]. These variations may be due to variations in laboratory methods and the type of staple under investigation. Soaking also removes other antinutritive factors, such as saponins, trypsin inhibitors, and polyphenols [33]. However, tannin-free whole-grain

TABLE 4. Effect of soaking unrefined maize flour and pounded maize on phytate, zinc, and calcium content[a]

Test	Maize flour (control)	Soaked maize flour	Soaked maize flour (% retained)	Pounded maize (control)	Soaked pounded maize	Soaked maize flour (% retained)
Phytate (mg $IP_6 + IP_5$/100 g)	710	306	43	697	342	49
Zinc (mg/100 g)	2.4	1.7	71	2.4	2.2	92
Phytate:zinc molar ratio	28.9	17.7	61	28.8	15.4	53
Iron	NT	NT	NT	4.2	4.4	107
Calcium	NT	NT	NT	4	7	175
Niacin	0.06	0.03	50	NT	NT	NT
Riboflavin	1.64	1.38	84	NT	NT	NT

a. NT, Not tested. Adapted from ref. 27.

sorghum soaked for 24 hours had 50% less phytates [34]. The absence of tannin facilitated the hydration of the grains and improved the loss of phytates.

The observation of reduced levels of phytates and increased availability of minerals provides scientific support for the traditional practice of soaking maize before milling and fermentation in the preparation of complementary foods. A second soaking of the milled flour in the preparation of Nigerian fermented maize dough could further reduce the levels of phytates, but this could have implications for food safety, since the antimicrobial substance resulting from fermentation of maize is water soluble and could be lost in the decanted water [35]. This is particularly important during storage of cooked food.

Safety

Enteropathogenic microbes could be transferred onto the grain if microbiologically unsafe water is used for soaking. Excessive handling of the grain after soaking, such as drying and exposure of the grain to wild birds and other animals, could compromise the microbiological quality of the grain. In Nigeria, soaking of maize flour during fermentation and removal of the excess water resulted in the loss of water-soluble antimicrobial substances. Thus, Nigerian fermented maize dough has reduced antimicrobial activity, as compared to Ghanaian fermented maize dough. There is an increased risk of contamination by food-borne pathogens.

Acceptability

Soaking of grains and pulses is a common practice in many communities and has been successfully introduced in rural Malawi [27].

Constraints

There are problems with the availability of adequate supplies of safe water. The process is time-consuming and requires extra cooking utensils.

Research needs

The acceptability of this method by communities needs to be evaluated. The effect of soaking whole grains and flour on antinutritive factors needs to be assessed. The effect of soaking on antinutritive factors and the chemical safety of roots, with special focus on the metabolic role of soil microbes in this process, needs to be evaluated.

Fermentation

Biology

Fermented foods are food substrates that are invaded or overgrown by edible microorganisms whose enzymes, particularly amylases, proteases, and lipases, hydrolyze the polysaccharides, proteins, and lipids to form non-toxic products and produce flavors, aromas, and textures that are pleasant and attractive to the consumer [36]. A variety of products are fermented worldwide, but fermented cereals, legumes, milk, and some fish products are of relevance in complementary food preparation. Examples of some common fermented foods are listed in table 5. Notable among these are *ogi* (Nigeria), *koko* (Ghana), *mahewu* (South Africa), *nasha* (Sudan), *obushera* (Tanzania), *njera* (Ethiopia), and *uji* (Kenya).

At the household level, fermentation occurs spontaneously as a result of the presence of a mixed microbial flora on the grain. The grain is soaked overnight to stimulate microbial growth. As the process progresses and the acidity increases, non-lactic-acid bacteria are eliminated. In certain cultures, such as Ghana, whole grains are soaked in water for up to 48 hours, creating an acidic (pH < 4.5) and anerobic environment for the selection of desirable lactic acid bacteria [37].

Bacteria of four genera—*Lactobacillus, Lactococcus, Leuconostoc,* and *Pedicoccus*—carry out the fermentation. These lactic acid bacteria utilize carbohydrates in fermentation and produce lactic acid as the major end product. The flora changes from the less acid-tolerant (*Lactobacillus plantarum*) to the more acid-tolerant (*Leuconostoc mensenteroides*) [38].

This ancient technology of food preservation has a number of benefits. It is a low-cost method of food preservation; it serves to improve food safety in the household; and it contributes to the improvement

TABLE 5. Examples of fermented foods[a]

Country	Food/substrate	Nature of food
Nigeria	*Ogi, akamu* (maize)	Porridge
Ghana	*Koko* or *akasa* (maize)	Porridge
	Kenkey/banku (maize)	Dumplings
South Africa, Kenya, Uganda, Tanzania	*Mahewu* (maize)	Beverage
	Uji (maize, sorghum and millet)	Porridge
Botswana	*Bogobe* (sorghum)	Porridge
Sudan	*Nasha* (sorghum)	Porridge
	Kisra (sorghum)	Bread
Uganda	*Obusera* (millet)	Porridge
Ethiopia	*Njera* (maize)	Pancake
Egypt	*Busa* (millet)	Not indicated
Tanzania	*Kito* (maize)	Porridge
West Africa	*Agblima* (cassava)	Dumpling
	Gari (cassava)	Flour
Mali, West Africa, Sudan, Ethiopia, Egypt	Fermented milk	Not applicable
Kenya, Nigeria	*Ugba* (oil bean seeds)	Flavor
	Dawada (locust bean)	Condiment
Germany	Sour bread (wheat)	
Denmark	Rye bread (rye)	
India, Sri Lanka	*Idli* (rice, black gum)	
Philippines	*Puto* (rice)	Steamed cake
Korea	*Kichudok* (rice)	Steamed cake
Ethiopia	*Enjera* (*tef* or other cereals)	Pancake
Sudan	*Kisra* (sorghum, millet)	Pancake
Egypt	*Kishk* (wheat + milk)	Dried balls
Sri Lanka	Hopper (rice/coconut water)	Stake-baked pancake

a. Adapted from ref. 36.

of the nutritional value and digestibility of raw food materials.

Nutrition. Fermentation improves the nutritional quality of foods by improving the nutrient density and increasing the bioavailability of nutrients. This is achieved by the production of phytases, degradation of antinutritional factors, predigestion of certain food components, synthesis of promoters for absorption, and enhancement of the uptake of nutrients by the mucosa [39].

Fermentation of pearl millet significantly reduced the starch content of the two cultivars, standard and Ugandi (table 2) [6]. The reduction was between 67% and 59% for the standard variety and between 68% and 67% for Ugandi. This may be attributed to the breakdown of starch by amylases produced by the microbes that carried out the fermentation [40]. The polyphenol levels were also significantly reduced from 304 to 12 mg/100 g and from 444 to 306 mg/100 g in the standard and Ugandi cultivars, respectively, after

14 hours of fermentation. The phytic acid levels were reduced by 59% in the standard variety and by 46% in the Ugandi variety. Fermentation has a greater effect on phytic acid than on other antinutritive factors because the acidic pH provides optimum conditions for phytase activity.

In vitro studies [41] showed that from 4% to 8% of soluble iron was released from low-tannin cereals as a result of fermentation. The sum of IP_6 and IP_5 was reduced (fig. 2). The reduction was about 50% in flour samples fermented with added germinated flour and more than 90% after soaking prior to fermentation. High-tannin cereals showed minor changes in soluble iron in comparison to low-tannin varieties. It seems that this is due to the high tannin levels that bind the free iron released from the grain, thus making it less bioavailable.

Several of the B group of vitamins, including thiamine, riboflavin, and niacin, are synthesized by bacteria, resulting in significantly increased levels in the
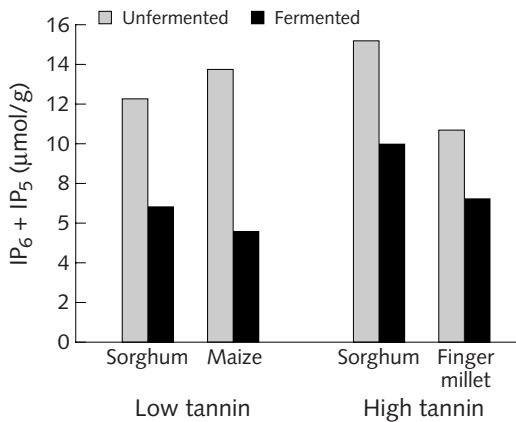
FIG. 2. Effect of fermentation on the sum of inositol hexaphosphate (IP_6) and inositol pentaphosphate (IP_5). Adapted from ref. 41

cereal during natural fermentation of sorghum, rice, pearl millet, and finger millet. However, considerable variations have been observed in different studies [42]. The amount of increase or decrease in vitamins appears to vary with the nature of the cereal, the microflora, the temperature, the length of fermentation, and the methods used for detection of these vitamins [39]. It is uncertain how much microbial synthesis contributes toward total micronutrient content, but it seems important among populations subsisting largely on maize (where niacin or nicotinic acid is limited and pellagra is a threat) or on polished rice (which contains limited amounts of thiamine) [36, 43].

Antimicrobial effects of fermented foods improve food safety. Fermented foods have antimicrobial properties, which make them potent inhibitory substances against a variety of food-borne pathogenic bacteria. They could also improve gut integrity, thus making the gut resistant to infection [44]. This subject has been reviewed in detail [45–47]. The complete inhibition of all coliforms in Kenyan *uji* after 24 hours, with a decrease in pH, has been documented [48].

A study on the antimicrobial effect of fermented maize dough on *Shigella flexneri*, enterotoxigenic *Escherichia coli*, *Bacillus cereus*, *Staphylococcus aureus*, *Vibrio cholerae*, *Salmonella* sp., and *Campylobacter jejuni* showed a significant reduction in the numbers of bacterial pathogens by four hours after inoculation [37, 49]. In community studies, unfermented and fermented maize dough complementary foods prepared by mothers in a Ghanaian village were examined for gram-negative bacilli immediately after preparation and during storage to assess the antimicrobial effect of fermentation. Gram-negative bacilli were cultured from 51 of 51 samples of unfermented maize dough [47] and from only 16 of 51 samples of fermented dough. The extent of contamination was significantly higher in unfermented dough than in fermented dough: 5.9 vs.

4.9 $\log_{10}$ colony-forming units (cfu)/g. A higher proportion (45 of 51) of samples of unfermented porridge than of fermented porridge (21 of 51) contained gram-negative bacilli after 6 and 12 hours of storage [37].

Uji, a fermented maize product from Kenya, showed complete inhibition of all coliforms after 24 hours, by which time the pH of the maize slurry had decreased to less than 4 [50]. The same product also significantly reduced the number of viable cells of *E. coli*, *St. aureus*, *Salmonella typhimurium*, and *Shigella dysenteriae* after five hours [48]. Odugbemi et al. found that *Salmonella paratyphi* were considerably inhibited by Nigerian porridge [51]. They concluded that the low pH of the porridge must have accounted for its inhibitory property. In a study in which *S. typhimurium* was inoculated into lactic-fermented sorghum, the organism was destroyed by storage at 30°C for 24 hours. Previous studies have shown that pH values below 4.0 are inhibitory to *Shigella* sp. and enteropathogenic *E. coli* in bacteriological media [52]. *Campylobacter* species have also been shown to die rapidly within 30 minutes in yogurt, a fermented milk product [53, 54], although they can survive for at least a week in unfermented milk. Studies have also shown that fermented milk can inhibit *St. aureus*, coliforms, *E. coli*, *C. jejuni*, and *V. cholerae*. *In vitro* studies from Mali on the antimicrobial effect of a mixture of curdled milk and millet porridge on *V. cholerae* showed complete inhibition of these organisms by six hours [54].

The lactic acid bacteria inhibit the growth of many food-borne bacterial pathogens. It is not known whether fermented foods are effective against viruses such as rotavirus and HIV. Limited studies show that rotavirus survives well in fermented foods [55], but there is no specific information on the effect of fermentation on HIV. If fermentation does affect viruses, the potential for preventing postpartum transmission of HIV by inhibiting the viruses in infected breastmilk is considerable. Mold growth on fermented foods such as fermented maize dough and cheese presents a potential health hazard due to the production of mycotoxins such as aflatoxins. A limited number of studies have shown that lactic acid bacteria affect mold growth and aflatoxin production. Some lactic acid bacteria of *Lactobacillus* spp. inhibit aflatoxin synthesis, but *Lactococcus lactis* stimulates aflatoxin production [56].

Certain lactobacilli degrade the cyanogenic glycosides that are often associated with root tubers [57, 58]. Several factors have been associated with the inhibitory activity of fermented foods, including low pH, organic acids, bacteriocins, carbon dioxide, hydrogen peroxide, ethanol, diacetyl, low redox potential, nutrient depletion, and crowding.

A cofermented maize–soy blend with malt thinner (F), nonfermented maize–soy blend (NF) plus malt thinner, and the traditional fermented porridge (P) were evaluated for acceptability and performance in

terms of macronutrient intake during primary recuperative feeding among children in pediatric wards in Ghana and Nigeria [35]. F and NF had greater nutrient density than P, whereas the energy content of Nigerian P was closer to that of NF and F due to the addition of fats and sugars. No such additions occurred in the Ghanaian study because the mothers in the study did not add sugar to the porridge. The mothers preferred fermented porridge (P), either as whole-meal porridge in Ghana or as partial maize starch extract in Nigeria, to both F and NF. F was rated lowest in all four attributes assessed: color, flavor, texture, and acceptability.

In Ghana, the total intake of protein and energy was greatest for F, followed by NF, followed by P. F and NF can therefore serve as suitable sources of improved nutrient supplies when compared to the traditional porridge. Since all the infants were breastfed, breast-milk together with the porridges should be adequate for satisfying increased need due to illness and catch-up growth.

Kingamkono [59] assessed the prevalence of enteropathogens in fecal swabs from 151 young, healthy Tanzanian children between 6 and 60 months of age. The intervention group was given lactic acid–fermented cereal porridge with a pH of 4.0 or less, and a control group was fed an unfermented porridge. The proportion of children who had stool samples positive for pathogens was reduced significantly from 27.6% at baseline to 7.8% on day 7, 8.2% on day 13, and 12.7% at follow-up 14 days after cessation of the feeding regimen. Among children receiving unfermented porridge, there was a statistically nonsignificant decrease in the percentage of those with positive cultures from 16.7% at baseline to 11.4% on day 7 and 8.1% on day 13. Consumption of fermented porridge once a day, three times a week, appears to reduce intestinal colonization with pathogenic bacteria.

Safety

Fermented foods are microbiologically safer than unfermented foods. By-products from certain fermented foods can be toxigenic. These include bongkrekic acid, ethyl carbamate, and biogenic amines. In central Java, *tempeh bongkrek* is made from coconut press-cake. It is notorious for causing food poisoning due to the production of bongkrekic acid and toxoflavin by *Burkholderia cocovenenans*. It is estimated that at least a thousand people have died since 1951 from this intoxication. Production conditions that increase the final pH to above 6.0 favor the growth of *B. cocovenenans* toxin, so food technologies like this must be avoided [36].

Ethyl carbamate, an established carcinogen, is produced during fermentation by a reaction of naturally occurring urea and carbamyl phosphate with ethanol. High levels of ethyl carbamate have been detected in Japanese soy sauces [60]. Fermented maize dough from Ghana was tested for ethyl carbamate, but the levels detected were insignificant [61]. This may be due to the absence of adequate levels of ethanol and/or precursors such as citrullen, arginine, or urea. Fermented foods free from these compounds can be used in complementary food preparation without any safety risk from ethyl carbamate.

Biogenic amines are formed in fermented foods by decarboxylation of amino acids. Lactic acid bacteria and the Enterobacteriaceae possess decarboxylases required for this reaction. Examples are ethylamine, putrescine, and histamine. Histamine is the most widely studied and is heat stable. They are especially associated with wine, cheese, fish, and meat fermentation, although low levels occur in fermented vegetables. Biogenic amine levels in fermented maize dough in Ghana were very low (60 ppm) but increased 10-fold after the addition of cowpeas. The addition of cowpeas increased the protein content but also introduced amino acid precursors and polyphenols. Prolonged cooking of maize dough lowered the level of amines only marginally [61]. Cowpeas are a common source of additional nutrients for complementary foods from developing countries, so this finding has serious implications.

Acceptability

Fermentation may not be acceptable in certain cultures because of its association with the brewing industry.

Constraints

Fermentation takes about four days and requires additional containers and utensils.

Research needs

Research needs include evaluation of the antimicrobial effect of fermented multimixes; assessment of acidified fermented proprietary foods, with or without probiotics, for inhibitory activity and microbial safety during storage under unhygienic conditions; and evaluation of the levels of ethyl carbamate and biogenic amines in fermented multimixes.

Germination and malting

Biology

Malting involves germination and sprouting of cereal and legume grains. The grain is soaked in water for up to 24 hours, during which the grain is rehydrated and a number of complex chemical reactions are activated. These include breakdown of stored starch, protein, and other materials required by the seed for growth; transport of materials across the seed; synthesis of vitamins; and increase in the availability of minerals and fat [62]. Flavor, cooking properties, and nutritional quality are altered by germination. Germination increases the vitamin content, resulting in improved bioavailability of niacin, riboflavin, and vitamin C [63]. Protein quality

and digestibility are enhanced [64–66].

The production of α–amylase, an enzyme that converts insoluble starch to soluble sugars, resulting in a thinning effect, is the most important nutritional effect of germination. Amylases convert starch to dextrins and maltose, the sequence of which depends on the relative amounts of amylopectin and amylose in the starch granules. The amount of α– and β–amylase produced by the germination process is also important. β–Amylase, acting on the 1:4 glycosidic linkages, breaks down amylose into maltose units. Its activity is limited because it can only split off maltose from the nonreducing ends of the amylopectin chain up to the 1:6 linkages, yielding maltose and high-molecular-weight dextrins as breakdown products. α–Amylase is also produced in the aleurone layer and migrates into the starchy endosperm. α–Amylase cleaves the 1:4 glycoside linkages at random, in addition to the 1:6 links of the amylopectin chains, to produce low-molecular-weight dextrin. These are broken down into maltose by β–amylase. The two enzymes complement each other, with α–amylase reducing the viscosity rapidly and β–amylase doing so slowly. The production of α–amylase varies among cereals and, after 24 hours of germination, pearl millet exhibited the highest amylolytic and proteolytic enzyme levels [67].

The products of starch hydrolysis described above do not gelatinize after cooking, so porridges from germinated grain can have a markedly reduced viscosity. As much as three times more starch-digested flour can be used to prepare porridge of the same consistency as normal non-starch-digested porridge, thus allowing a higher nutrient density in porridge paste of a given viscosity. This is useful in overcoming the problems that children have in consuming bulky, low-nutrient-dense porridges.

Malted cereals, alone and in combination with pulses, were initially used to improve the nutritional quality of complementary diets [68]. More recently a mix made by adding small quantities of amylase-rich flour (ARF) to nongerminated flour has been used [69–72].

A porridge containing 5% dry matter provides only 0.2 kcal/g, which is much lower than that provided by breastmilk (0.67 kcal/g). Thus, anything that can increase the nutrient density while maintaining a viscosity that allows infants and young children to swallow the food is worth exploring [68]. This undisputed effect should increase nutrient intake and will be evaluated by discussing the use of ARF-treated porridge in infant feeding studies.

In a detailed review of studies on malting or germination, Ashworth and Draper [73] noted the conflicting nature of the findings from studies that sought to evaluate the effect of amylase-rich flour on energy intake. They suggested that the differences in energy intake between studies could be due to differences in the thickness of the initial porridge and the ages of the children studied, and that malting has the potential to increase the energy content of complementary foods, but its effect on the actual nutrient intakes of young children had not been fully investigated.

A number of studies have been conducted since this publication [74–76], and all showed that germination could lead to increased nutrient intake. Twenty-four children aged between 6 and 10 months from Ouagadougou, Burkina Faso, were given five experimental complementary foods prepared from millet, sucrose, soybean, peanut, and salt to evaluate the effect of energy density and sweetness on energy intake [76]. The composition of the flours used in the preparation of the diets (G0, G1, G9, and G20) is shown in table 6. Industrial amylase (BAN 800 MG) was added to G1

TABLE 6. Characteristics of porridges and their mean energy intakes[a]

Flour composition or nutrient content	G0	G1[b]	G9[b]	G20[b]	GC
Millet (g/100 g)	66.3	74.3	66.3	55.3	—
Sucrose (g/100 g)	9.0	1.0	9.0	20.0	—
Soybean (g/100 g)	19.0	19.0	19.0	19.0	—
Peanut (g/100 g)	5.0	5.0	5.0	5.0	—
Salt (g/100 g)	0.7	0.7	0.7	0.7	—
Dry matter content[c] (g/100 g)	10.2 ± 0.8	25.4 ± 1.0	25.1 ± 1.4	25.5 ± 1.4	24.1 ± 0.7
Lipid content (g/100 g)	1.1	2.8	2.6	2.5	2.0
Protein content (g/100 g)	1.7	4.5	4.2	4.0	3.8
Carbohydrate content (g/100 g)	6.9	16.4	16.9	17.8	17.3
Saccharose (g/100 g)	1.0	0.3	2.4	5.3	NS
Energy density (kcal/100 g)	44.5 ± 3.2	109 ± 4.3	108.4 ± 6.8	108.6 ± 6.2	102.3 ± 3.2
Mean energy intake (kcal/100g)	24.9 ± 11.9	35.1 ± 21.3	44.2 ± 33.7	48.6 ± 33.9	35.7 ± 34.9
Energy intake (kcal/kg/meal)	3.5 ± 1.7	4.9 ± 3.0	6.1 ± 5.1	6.6 ± 4.7	4.8

a. G0, Medium sweetness with no amylase; G1, low sweetness; G9, medium sweetness; G20, high sweetness; GC, Cérélac, proprietary flour of wheat, milk, sucrose, and palm oil, without added amylase; NS, not specified. Adapted from ref. 76.
b. Industrial amylase (BAN 800 MG) added.
c. Mean ± SD from data on 140 porridge samples (consumed by the infants).

(low sweetness), G9 (medium sweetness), and G20 (high sweetness). The fourth experimental food (GC) was Cérélac (Nestlé, Ivory Coast), a proprietary flour of wheat, milk, sucrose, and palm oil, without added amylase. Each child received the five experimental porridges for three days twice daily and was followed for 2.5 weeks.

The energy intakes from the five foods are presented in table 6. The energy intakes from the high-energy-density gruels G1, G9, and G20 (4.9, 6.1, and 6.6 kcal/kg/meal, respectively) were higher than that from G0 (3.5 kcal/kg/meal). The energy intake from Cérélac was only 4.8 kcal/kg/meal. Although the energy intake from some of these foods was greater than that from others, it should be noted that micronutrients were not added, and thus the ratios of energy to micronutrients deteriorated despite the additional energy intake.

In order to evaluate the independent effects of dietary viscosity and energy density on total daily energy intake, 18 young children aged 8 to 17 months from Lima, Peru, participated in three different substudies [75]. The children who were given high-density, low-viscosity foods had greater energy intakes in the various studies (ranging from 145 to 155 kcal/kg body weight/meal) than the children who received high-density, high-viscosity foods (105 to 125 kcal/kg/meal) or low-density, low-viscosity foods (105 to 120 kcal/kg/meal) (fig. 3).

The authors noted a number of factors that could modify the effect of dietary characteristics on total energy intake of the study group. These included age, nutritional status, level of physical development, neurological development, presence of infection, and greater energy requirement as a result of illness.

A study of energy intake among 75 Tanzanian children aged 6 to 25 months with diarrhea examined the impact of feeding conventional maize porridge, amylase-digested porridge, or porridge that had been fermented and amylase digested. The mean daily energy intakes from these three foods were 32, 46, and 37 kcal/kg body weight, respectively. Although these children were fortunately also receiving breastmilk, the additional benefit of the malting process on energy intake from porridges is clearly shown [74]. A concern that is often expressed is whether amylase digestion might lead to large amounts of dextrins and sugars in the intestinal tract, which might cause osmotic diarrhea. This study showed no difference in the duration of diarrhea or the frequency of severity of stooling.
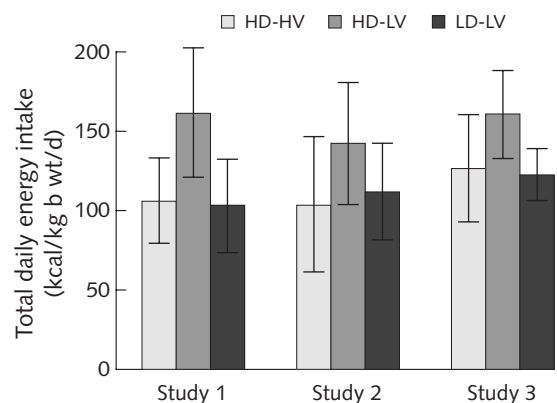
A further benefit of the germination process has been examined in Malawi. In the study by Hotz and Gibson [27] (details given in the section on Soaking), germination of maize flour reduced phytate levels by 46%. The HCl extractability of calcium and iron increased by about 100% after germination of pearl millet. This is a result of hydrolytic dismutation of phytic acid in finger millet [31].

A number of factors could be responsible for the difference in findings between studies. Several were conducted under tight clinical investigative conditions in which the foods were carefully weighed, prepared, and fed by trained personnel. There were differences in the degree with which mothers were involved in the design and implementation of the studies.

Safety

Soaking the grain helps remove dirt, but it does not eliminate bacteria or fungi. Indeed, pathogenic and toxigenic bacteria and fungi could multiply during the germination process, so care must be taken to adequately heat porridge with added germinated flour before use.

Germinated sorghum flour produces small amounts of cyanogenic glycosides. When hydrolyzed, dhurrin produces prussic acid, hydrocyanide (HCN), and cyanide, a phenomenon first reported by Panasiuk and Bill [77]. However, the cyanide levels are significantly reduced by toasting at 180°C for 15 minutes or heating at 100°C, the temperature for cooking complementary foods [78]. Nineteen varieties of sorghum were reported to have HCN levels of 74 to 826 ppm [78]. There is little evidence of the impact of this on infant nutrition, but in studies of children fed germinated sorghum in Tanzania, none had detectable levels of urinary thiocyanate. Although exposure to high levels of cyanide, such as those found in certain strains of cassava, is associated with nutritional neuropathy and goiter [79], especially in persons with low intakes of sulfur amino acids, the neurological lesions have been documented only in cases in which the roots were not properly soaked and fermented.

FIG. 3. Total daily energy consumption (± SD) by study. Diets: HD-HV, high density, high viscosity; HD-LV, high density, low viscosity; LD-LV = low density, low viscosity. Adapted from ref. 75

Acceptability

Germination is often associated with beer brewing and may not be acceptable in certain cultures.

Constraints

The process is time-consuming.

Research needs

The possible development of osmotic diarrhea among children eating germinated flours needs investigating. Studies on the level of exposure of infants to HCN as a result of consumption of germinated flour as porridge or as a porridge thinner are required.

Enrichment

Biology

Enrichment refers to the addition of specific nutrients to a food. The amounts added are generally moderate and may add to those that are already present in small amounts. Fortification, on the other hand, refers to the addition of specific nutrients to foods in excess of those normally found in the food because of the importance of providing additional amounts of nutrients in the diet. The two terms are often used interchangeably to signify the addition of nutrients to foods that contain suboptimum quantities of nutrients.

A large variety of oilseed and pulses, including cowpeas, groundnuts (peanuts), pigeon peas, and melon seeds, are grown in many developing countries. Soybeans abound in Asia and have increased in popularity in many African countries in recent years. A composite complementary food made from a combination of legumes and cereals is a nutritionally improved product in which the legumes complement the limited lysine in cereals and the cereals provide sulfur-containing amino acids that are low in legumes. Several formulas using legumes alone or in combination with cereals have been prepared [19, 80–83]. A number of projects have been set up worldwide with support from international agencies and nongovernmental organizations. These projects have produced composite complementary foods from roasted or fermented cereals, legumes, and milk [84].

In Ghana, the Nutrition Unit of the Ministry of Health and the United Nations Children's Fund (UNICEF, Ghana) introduced Weanimix in 1987. Weanimix is a cereal–legume blend composed of 10% to 15% soybeans or cowpeas, 10% groundnuts (peanuts), and 75% to 80% maize (corn) (fig. 4). Although Weanimix is an improved product with respect to nutrient content compared with the traditional porridge, it is high in fiber and phytates. The estimated phytate:iron and phytate:zinc molar ratios are 7.3 and 17, respectively [85]. Phytates chelate divalent and trivalent cations such as calcium, iron, and zinc, thus impairing their absorption and bioavailability. In addition, Weanimix is low in vitamin A (0.36 mg retinol equivalent/kg) and riboflavin (0.4 mg/kg). The cost of Weanimix may also make it unavailable to the average
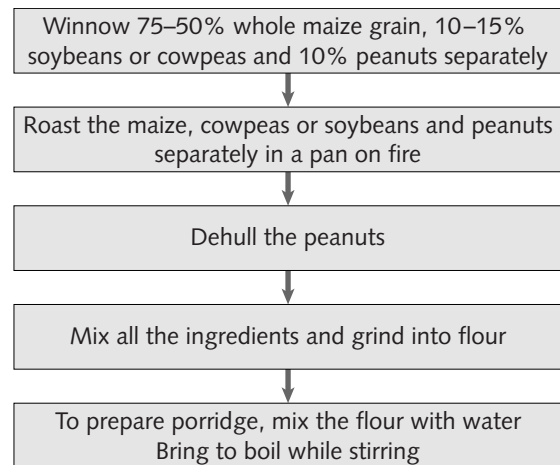

FIG 4. Preparation of Weanimix

Ghanaian mother, hence the apparent low coverage. It is used largely in hospital nutrition rehabilitation centers. Information on targeting and coverage appears to be unavailable at the moment [84].

In the preparation of nutritionally adequate complementary diets, foods are selected on the basis of availability at the household level and cultural acceptability. Recipes for complementary foods may also be formulated and field-tested in a participatory process. A variety of foods may be used as additional sources of mineral and vitamins, e.g., meat, offal, dark-green leafy vegetables, orange-fleshed vegetables, fruits, tubers, oils, and fats. A number of trials of improved complementary foods have been conducted, and these are described below.

Most studies that assessed the influence of enrichment of foods on infant growth in the past yielded mixed results because of overemphasis on the provision of food alone without simultaneously addressing other factors such as food safety, caregiving practices, and the micronutrient content of the diets. An intervention trial was conducted to assess the effect of complementary feeding on the growth of 208 breast-fed Ghanaian children [85]. The study design was a randomized intervention trial of four groups. Infants six months of age were recruited for the study. The following local maize-based foods were used: Weanimix (W), prepared with 75% roasted maize, 15% soybeans, and 10% peanuts (fig. 4); Weanimix, fortified with vitamin-mineral premix and additional iron (as electrolyte iron), potassium (as potassium citrate), calcium, and phosphorus (as dicalcium phosphate)(WM); and fermented maize dough porridge (*koko*) with fish powder from smoked anchovies (KF). Weanimix contains 7.3 and 17 molar ratios, respectively, of Phy:Fe and Phy:Zn, vitamin A (0.36 mg retinol equivalent/kg), and riboflavin (0.4 mg/kg).

Acceptability trials of the foods were conducted

to ensure that the foods were acceptable to mothers and infants. Morbidity data were collected by weekly monitoring, and vacuum flasks were provided for food storage to prevent food contamination. Food intake was monitored regularly by weighed food records and 24-hour recalls, and the mothers were encouraged to breastfeed into the second year of life. The outcomes of the intervention were assessed by growth, micronutrient status, and morbidity.

Data from weighed food records for about 50% of the subjects showed that the project food provided 119 to 261 kcal/day, approximately 40% to 78% of the total nonbreastmilk food intake. The energy intake in the WM group was higher than in the WF group at seven months (186 vs. 171 kcal). At eight months, the intake of project food was not significantly different in the four groups, but this changed at 12 months as WM provided more energy than KF (380 ± 233 vs. 341 ± 146 kcal, respectively) ($p < .05$).

Iron, zinc, vitamin A, and riboflavin intakes were significantly higher in the group fed the fortified product (WM). The intakes of these micronutrients were not significantly different in the W, KF, and WF groups, but at seven months the iron and zinc intakes were higher in the KF group than in the W group (3.4 vs. 3.2 mg; $p < .05$). The intake of riboflavin was higher in the WF than the W group (0.06 vs. 0.02 mg; $p < .05$). There was an increase in the consumption of nonproject foods by 12 months, but WM contributed more than 75% of the total micronutrient intake.

Table 7 shows a general decline in the mean hemoglobin, hematocrit, plasma ferritin, and erythrocyte riboflavin levels between 6 and 12 months. The plasma retinol levels improved by 0.14 µmol/L in the WM group, a statistically significant difference from the change in plasma retinol levels in the WF, KF, and W groups. Plasma zinc improved in the W, WF, and KF groups but worsened by 1.1 µmol/L in the WM group. The prevalence of low zinc levels decreased by 3.3% in children receiving W but increased by 6.9% in those receiving KF and 6.7% in those receiving WM.

The prevalence of infants with low ferritin increased significantly between 6 and 12 months in the W, WF, and KF groups but decreased by 7.2% in the WM group. There was a significant decrease (24.1%) in the prevalence of low retinol levels among children fed WM. Despite the improvements in some biochemical indices, the project foods did not have any significant effect on growth, reported as weight-for-age and length-for-age Z scores. These findings showed that there are factors other than food availability that impact negatively on food intake and nutritional status.

The traditional Nigerian porridge was fortified by the addition of roasted cowpea flour, red palm oil, and sugar and evaluated in a face-to-face intervention study in Kwara State, Nigeria [86]. As a result of a

TABLE 7. Changes in hemoglobin, hematocrit, plasma transferrin saturation, plasma ferritin, plasma zinc, plasma retinol, and erythrocyte riboflavin levels, according to intervention group[a]

Biochemical index	W	WM	WF	KF
Hemoglobin (g/L)				
6 mo	105	104	106	108
12 mo	100	104	103	105
Difference	−5	0	−3	−3
Hematocrit				
6 mo	0.339	0.338	0.334	0.346
12 mo	0.330	0.336	0.340	0.343
Difference	−0.009	−0.002	−0.004	−0.004
Plasma transferrin saturation (%)				
6 mo	37	42	36	38
12 mo	39	33	38	39
Difference	2	−9	2	−1
Plasma ferritin (µg/L)				
6 mo	26.2	32.0	29.9	28.5
12 mo	14.6	22.1	14.9	12.1
Change (%)	−5	−31	−49	−55
Plasma zinc (µmol/L)				
6 mo	15.5	15.6	14.7	15.6
12 mo	15.7	14.4	15.9	15.8
Difference	0.2	−1.1	0.8	0.2
Plasma retinol (µmol/L)				
6 mo	1.01	0.81	0.85	0.94
12 mo	0.93	0.98	0.84	0.92
Difference	−0.08	0.14	−0.01	−0.03
Erythrocyte riboflavin (nmol/L)				
6 mo	283.4	285.3	268.2	266.7
12 mo	283.3	278.1	262.1	252.0
Change (%)	−0.05	−2.5	−2.2	−5.9

a. W, Weanimix (cereal–legume blend); WM, W plus vitamins and minerals; WF, W plus fish powder; KF, *koko* (fermented maize dough) plus fish powder. Adapted from ref. 85.

nutrition-promotion intervention for six weeks, 57% of the participating mothers came to know the modified recipe, 48% had tried it, and 17% used it regularly. Only 2% of the nonparticipating mothers knew about the recipe. The critical factors for successful learning about the technology and using it included the mothers' education, perceptions of cost, and the time for preparation.

Orange-fleshed sweet potatoes were introduced as a food-based intervention to increase vitamin A intake in rural Kenya. The intervention was through women's groups that selected the variety of sweet potatoes in

pilot trials. The Helen Keller International scores for provitamin A intake showed that the intervention group increased significantly (+1.6 points) from pre-intervention to postintervention, while the score in the control group decreased (–1.3 points). The net increase of 2.9 points (93%) over the preintervention was highly significant. The consumption of animal foods also increased as the income from sales of orange-fleshed sweet potatoes enabled the women to buy animal products. No data were reported on the biochemical vitamin A status of the subjects.

A food-based vitamin A intervention in Burkina Faso used imported palm oil [87]. The subjects were 207 mother–child pairs, and targeted messages were given to both women and men by the media and through community-level social marketing activities. Vitamin A–related knowledge improved significantly after one year of project operation. The vitamin A intake doubled in the mothers but trebled in the children between baseline and the second survey. The percentage of subjects at risk was reduced from 83% to 38% among mothers and from 88% to 49% among children. Postintervention data on serum retinol levels were not available for comparison. An added benefit of the program was the financial empowerment of the community as a result of 8% profits from the retail sale of palm oil.

In South Delhi (India), a food-based intervention study evaluated the effect of the provision of generous amounts of a micronutrient-fortified food supplement coupled with counseling on the physical growth of infants between 4 and 12 months of age [88]. A total of 368 children who completed the study were enrolled at the age of four months and assigned to one of four groups. The supplementation group received milk cereal supplement (milk cereal enriched with minerals and vitamins packaged in 50-g portions) and advice on hygienic preparation, feeding frequency, and nutrition; the mothers were to add 50 ml of warm water at the time of offering the food to the children. The counseling group received 30 to 45 minutes of nutritional counseling monthly. The visitation group received twice-weekly visits to assess morbidity and no nutrition counseling. The members of the nonintervention group were contacted at 6, 9, and 12 months for anthropometric data collection and dietary recall.

In comparison with infants in the visitation group, infants in the supplementation group had a 250-g greater weight gain, a 0.4-cm greater increase in length, a similar prevalence of wasting, and a 6.8% lower prevalence of stunting. In comparison with infants in the nonintervention group, infants in the supplementation group had a 100-g greater weight gain and a 0.4-cm greater increase in length. Nutritional counseling had no significant effect on weight and length in either the visitation or the nonintervention groups. The

counseling group gained 90 g more than the visitation group. The maximum benefit was derived from food supplementation between 26 and 38 weeks, and there was little impact of supplementation from 16 to 26 weeks and from 38 to 52 weeks. This shows that there is a critical age for effective nutrition intervention at 26 to 38 weeks.

Figure 5 illustrates the median total nonbreastmilk energy intakes in the different study groups at 26, 38, and 52 weeks. The median total nonbreastmilk energy intake per day from supplements and usual foods based on 24-hour dietary recalls was higher in the food-supplementation group than in the visitation group by 289.8 kcal at 26 weeks, 414.0 kcal at 38 weeks, and 537.3 kcal at 52 weeks. The median energy intakes per day estimated at 26, 38, and 52 weeks from reported consumption of food packets were higher by 35% to 72% than the estimates from 24-hour recall. Data from the 24-hour dietary recalls showed that the median intake of supplement was similar at 26, 38, and 52 weeks. It is therefore possible that the infants did not consume all of the food from the packets.

Overall, the proportion of children who were breast-fed as well as the mean breastfeeding frequency was lowest in the supplementation group. The prevalence of fever and dysentery was highest in the supplementation group. These children would have lost the protective effect of breastmilk, and the use of contaminated water (despite the advice to boil water used to prepare food) explains the increase in dysentery and fever in the supplementation group.

This study showed that the provision of food alone does not always improve the nutritional status of at-risk groups. Factors that must be considered in future interventions include the introduction of a supplement at 26 to 38 weeks, the use of 24-hour recall food-intake data or actual observational studies, and encourage-
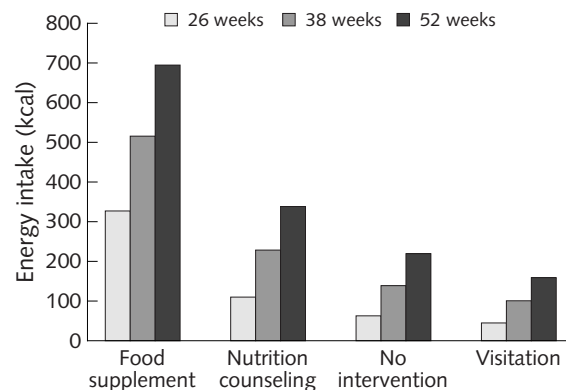

FIG. 5. Energy intake from nonbreastmilk sources ascertained by 24-hour dietary recall at different ages. Adapted from ref. 88

ment of mothers to continue breastfeeding to avert the risk of increased morbidity.

The barriers associated with acceptance of novel foods, as suggested by the researchers, could also be a problem. Another reason for low food intake is the lack of appetite as a result of micronutrient deficiency and sickness [89]. The mothers also may have found it difficult to use the food as directed because the selection of the diet was carried out in a nonparticipatory manner.

Enrichment of staples to improve nutrient intake is widely practiced by industry, e.g., fortification of fat spreads with vitamins and minerals. A peanut spread enriched with micronutrients has been widely accepted in preliminary studies [90]. Since peanut butter and several such products are readily available in many countries, cheaper methods of fortification (e.g., in village or cottage industries) require evaluation to make such products more affordable.

Complementary foods may contain micronutrients from cooking utensils as well as from the food itself. The effects of eating foods cooked in iron pots on 195 children aged 31 months were compared with the effects of eating foods cooked in aluminum pots on 212 children aged 30 months in Ethiopia [91]. The foods consisted of legumes, meat, vegetables, and *njera* from *teff*. The improvement in hemoglobin concentration was greater in those eating food from iron pots (mean change to 12 months, 1.7 vs. 0.4 g/dl). The mean weight and length gains were also significantly higher. Twenty-three Brazilian children aged 4 to 12 months who received legumes, cereals, meat, liver, and vegetables cooked in iron pots were compared with a control group of 22 children of similar age who received the same foods cooked in aluminum pots [92]. The iron intake in the group receiving food from iron pots was 1.3 g/dl more than that in the group receiving food from aluminum pots, but the increased iron intake was insufficient to result in differences in hemoglobin. Despite these technical benefits of iron leached from the pot into the food, iron cooking pots easily become rusty, and therefore acceptability studies are recommended before active promotion.

Safety

Enrichment foods such as meat, milk, and eggs could be sources of enteric pathogens. Their microbial safety must be assured before being fed to infants.

Acceptability

There should be no problem with acceptability, since locally available produce is often used to enrich complementary diets. The formation of rust in iron cooking pots might discourage their use.

Constraints

Food availability during off seasons could reduce the use of other sources of nutrients. Costs could also prevent the adoption of some of the proposed enrichment strategies.

Research needs

Acceptability and iron toxicity as a result of prolonged usage of iron cooking pots need to be assessed, and the use of nontraditional produce for complementary food enrichment needs to be exploited.

Vacuum flasks for storage of cooked food

Biology

In most communities, infant food is prepared once a day and stored for feeding over prolonged periods. This is because most mothers are very busy with household work and may also have to earn money away from the home in order to buy food. In addition, the cost and scarcity of food supplies and fuel make it uneconomical to prepare fresh food for a single infant at each meal.

Data from 649 Ghanaian mother–child pairs in an urban high-density community showed that 79% prepared infant foods once a day and stored them for up to 24 hours. There was a strong association between storage of food for more than four hours and the likelihood of a child suffering from acute diarrhea (relative risk = 1.48) and persistent diarrhea (relative risk = 2.2) [93]. This is because the infant foods become contaminated with bacteria which multiply during prolonged storage.

In communities where there are no refrigerators for storage, food is often stored at ambient temperature in the pots used for cooking or in plastic containers. Vacuum flasks are also used. Mothers in a village in Accra prepared porridge and stored it for up to 12 hours. Forty mothers stored the food in cooking pots and 11 used plastic containers. Two mothers poured hot food at around 87.5°C into vacuum flasks. This allowed storage for up to 12 hours with little or no contamination. Storage of hot porridge in vacuum flasks prevents contamination and multiplication of bacteria. The porridge could be poured out from the flasks when required, thus reducing the likelihood of contamination from spoons and hands. Food stored in other containers often cooled quickly in the tropical ambient temperature (28°–39°C), which allowed the bacteria to multiply [37].

A detailed study was conducted by Kimmons et al. [94] in Ghana to evaluate whether storage in vacuum flasks rather than in plastic containers and cooking pots reduced coliform contamination in fermented maize dough and unfermented porridge (Weanimix). The contamination rates for food stored in plastic containers and cooking pots were 25% for fermented maize dough and 48% for Weanimix. For foods stored in vacuum flasks, the respective rates of contamination were 13% and 42%. All pairwise comparisons were

significant except for that between Weanimix in plastic containers and cooking pots and Weanimix in vacuum flasks. When the temperature of the food in the flask fell below 50°C, the rate of contamination of Weanimix in vacuum flasks was 85%.

Safety

Inappropriate use of vacuum flasks, e.g., putrefaction of the food in the flask, inadequate cleaning, and use of leaky flasks, could nullify the benefits from reduction of contamination in complementary foods.

Acceptability

The use of vacuum flasks is a simple and convenient method for storing cooked food, and there should be no problem with its acceptability.

Constraints

The cost of vacuum flasks may make them unavailable to some households. Inappropriate use of flasks or lack of cleanliness of the flasks could create a health risk.

Research needs

Studies on vacuum-flask storage have been conducted in Ghana only, and there are no reported studies of this simple and cheap technology from other places. Data from other settings are required. An evaluation of the microbial quality of foods in vacuum bottles, according to the temperature of storage, and in different environmental settings is needed.

Discussion

A critical factor for ensuring satisfactory growth, micronutrient status, and development in the breastfed infant is the provision of nutritionally improved complementary foods from the age of six months onwards. This paper has discussed the application of household-level food-preparation technologies for achieving this goal. Dehulling, soaking, drying, fermentation, and germination are often used either separately or in combination to increase nutrient content and reduce antinutritive factors. Fermentation and vacuum storage reduce microbial contamination and proliferation.

Some well-designed studies have indicated improvements in the nutrient content and bioavailability of complementary foods, but a few showed only modest or minimal change in nutritional status [74, 75, 85, 86, 88]. Dewey's [89] commentary on the paper by Bhandari et al. [88] pointed out a number of factors that could account for the lack of impact in some trials. These include targeting interventions too early (well before six months of age) or too late (well after six months) and methodological limitations, such as small sample size and short duration of the intervention or attrition bias.

The study by Lartey et al. [85] showed that enrichment with micronutrients does not necessarily improve nutrition. Despite the use of satisfactory technologies, the nutrient intake from complementary foods may still be low because of barriers that hinder acceptability [88]. These include cultural beliefs and traditions, education, and perceptions of the cost and length of time for preparation of the recipe [86]. Cereal-based foods may lack certain attractive organoleptic properties. Household-level food technologies can help improve them, but the involvement of mothers at all stages of introduction of new technologies is vital.

In certain cultures, sour fruits, many kinds of fish and meat, and carotene-rich foods, especially papaya, are not given to children because they are believed to cause skin diseases and malaria. Among the nonmilking people of Africa and Asia, the milking of animals is considered to deprive the young animal of its source of food and could attract divine retribution [95].

Food technologists are often confident that they can improve complementary foods on the basis of scientific knowledge alone, but the reality is often different. Changes in the nutrient contents of complementary foods should be introduced with care. The successful introductions of orange-fleshed sweet potatoes and solar-dried mangoes and green vegetables to rural communities in Kenya and Tanzania are examples [20, 21]. Considerable effort was taken to involve the food preparers in the design of the intervention. Interestingly, the introduction of income generation as a result of the new food technology was a key factor in the successful introduction of palm oil in Burkina Faso [87].

Cereals are the predominant source of energy, protein, iron, zinc, niacin, and riboflavin for most children in the world [28]. Other products, such as vegetables, certain tubers, legumes, eggs and dairy products, meat and poultry, and fish, have a high nutrient content and should be promoted wherever possible, but in practice most people cannot afford them.

Several root tubers, such as sweet potatoes, cocoyams, and yams, are used to prepare a popular Ghanaian complementary food called *mpotompoto*. This is a mixture of boiled yams, potatoes, and sweet potatoes with fish or meat, vegetables, and palm oil, all mashed or pureed together for feeding to young children. If the ingredients are used in adequate quantities, a thick, nutrient-dense porridge is obtained. The addition of amylase-rich flour to the mixture will reduce the viscosity and also increase the nutrient content. The energy, nutrient, and antinutrient contents of multimixes based on maize, rice, starchy roots, and tubers were calculated by Gibson et al. [1].

For the millions of children in poor countries, cereals will continue to be the major source of nutrients for many years to come. Food-processing technologies, such as dehulling, soaking, drying, dry roasting or toasting, fermentation, and germination, have been

used for centuries, and they improve the nutritional quality and safety of complementary foods. Unfortunately, the use of these technologies appears to be declining as the use of convenience foods and street foods becomes more popular. There is a need to document the methods of preparation of these foods for posterity, and an urgent need to actively promote the use of these traditional methods of food preparation and preservation.

Because of constraints such as limited time, food, and fuel, mothers often find it difficult to cook separate meals for only one child. They therefore increasingly use street foods as complementary foods for their children. In Ghana, 30% to 45% of mothers used cooked foods purchased on the street as complementary foods [96]. There is a need to assess whether street-food vendors can use household-level food technologies more effectively. A detailed study of the microbiology of street foods in Ghana found that the levels of bacterial contamination were unacceptable and that the vendors were carriers of a number of enteric pathogens [97, 98]. There are similar reports from Nigeria, the Philippines, and Egypt [99-102].

Draper reported that the potential for street-food vendors to improve the nutritional quality and safety of their foods remains totally unexploited [103]. Street foods cover a wide range in terms of what is available and the ingredients they are made from, and a variety of procedures, such as dehulling or peeling, soaking, fermentation, germination, smoking, and drying can be applied in their preparation. It seems that ingredient-based enrichment by some form of centralized processing would be possible. Food-based enrichment might be suitable for populations that use community kitchens.

The data reviewed in this paper confirm the important role that women play in the provision and preparation of food for both the household and the community. In Africa and Asia, women have the sole responsibility for food preparation. Women also make major contributions to food production by performing agricultural work on subsistence crops and cash crops, gathering wild crops and cultivating secondary crops for periods of preharvest and crop failure, producing crops such as sweet potatoes, earning cash to buy food, and processing and selecting processed food [104].

Increasing the resources for women to carry out these roles through provision of income, production-focused inputs, labor-saving technologies, microfinance, social networks, and better organization of women's human capital could all contribute to improvements in the nutrient content and safety of complementary foods [104].

Infant growth-faltering and micronutrient deficiency during the complementary feeding period remain problems in the developing world. Microlevel or household-level food-processing technologies exist for the assurance of nutrient adequacy and safety of complementary diets. These include dehulling and peeling, soaking, smoking, solar drying, germination and malting, and vacuum storage. Multipronged strategies are needed to address the problem, and these must be viable, sustainable, and culturally acceptable. They cannot be implemented as stand-alone activities, but should be introduced in relation to issues of social development, poverty reduction, and equity.

Recommendations

On the basis of the above, the following practical recommendations are made:

Promote the use of soaking and/or fermentation of cereals.
Cereal flours and whole grains may be processed provided the sensory properties are culturally acceptable. This will reduce the Phy:Zn and Phy:Fe molar ratios, and mineral availability will be enhanced. The antimicrobial and other nutritional effects are emphasized.

Enrich porridges with soaked legumes.
This removes the antinutritive factors from legumes and improves nutrient bioavailability.

Encourage the addition of amylase-rich flours to cereal-, root-, and tuber-based complementary foods.
This will reduce the viscosity without dilution with water and thus increase the nutrient content.

Encourage preservation of fish by drying and smoking.
Small, soft-boned fish, such as anchovies and *Sardinella sp.*, as fish powder can be used to enrich various recipes of complementary foods.

Explore the promotion of other staples and recipes for complementary food preparation.
This will add variety to an otherwise monotonous diet, often prepared from cereals.

Encourage home gardening, including small-scale animal husbandry, raising poultry, and fruit and vegetable farming.
This will improve food security.

Encourage safe food preparation and storage.
This will prevent microbial, chemical, and physical contamination of foods and thus reduce diarrhea.

Explore the possibility of producing locally acceptable labor-saving equipment.
This includes labor-saving equipment for dehulling and milling, energy-saving stoves, food mixers (to puree solid complementary foods), and pressure cook-

ers (where feasible, to shorten cooking time). These will reduce the work of women and save time for preparation of complementary food and child care.

Prepare a national complementary food action plan.

In order to consolidate the gains from research and programs, countries should:

» Prepare a comprehensive action plan, taking into consideration the culture and the availability of food, knowledge, time, and resources for food preparation;
» Document what is locally acceptable from cultural, biological, safety, and nutritional perspectives;
» Document the types of nutrient-dense foods suitable for infant feeding;

» Document the food-processing technologies and how they are applied in complementary food preparation;
» Communicate these results and recommendations widely through existing networks.

Acknowledgments

References

1. Gibson RS, Ferguson EL, Lehrfeld J. Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvemnt. Eur J Clin Nutr 1998;52:764–70.
2. Kibona N, Doland C, Watson FE, Alnwick D, Tomkins A. An evaluation of a project to improve child nutrition in Tanzania. Int J Food Sci Nutr 1995;46:233–9.
3. Lutter CK. Macrolevel approaches to improve the availability of complementary foods. Food Nutr Bull 2003;24:83–103.
4. Perten H. Practical experience in processing and use of millet and sorghum in Senegal and Sudan. Cereal Foods World 1983;28:680–3.
5. Dada L, Dendy DA. Preliminary study of effect of various processing techniques on cyanide content of germinated sorghum. Trop Sci 1987;27:101–4.
6. El Hag ME, El Tinay AH, Yousif NE. Effect of fermentation and dehulling on starch, total polyphenols, phytic acid content and *in vitro* protein digestibility of pearl millet. Food Chem 2002;77:193–6.
7. Dhanker N, Chauhan BM. Effect of temperature and fermentation time on phytic acid and polyphenol content of *rabadi*, a fermented pearl millet food. J Food Sci 1987;52:828–9.
8. Hulse JH, Laing EM, Pearson OE. Sorghum and the millets: their composition and nutritive value. New York: Academic Press, 1980.
9. Hasan S, Gant C. Allergy to nuts: How much of a problem is this? (Editorial). Clin Exp Allergy 2001;31:5–7.
10. Pumphrey RSH, Stanworth S. The clinical spectrum of anaphylaxis in Northwest England. Clin Exp Allergy 1996;26:1364–70.
11. Emmett SE, Angus FJ, Fry JS. Perceived prevalence of peanut allergy in Great Britain and its association with other atopic conditions and with peanut allergy in other household members. Allergy 1999;54:380–5.
12. Sicherer SH, Burks AW, Sampson HA. Clinical features of acute allergic reactions to peanut and tree nuts in children. Paediatrics 1998;102:1–6.
13. Sicherer SH, Sampson HA, Burks AW. Peanut and soy allergy: a clinical and therapeutic dilemma. Allergy

2000;55:515–21.
14. Arshad H, Gant C. Allergy to nuts: How much of a problem really is there? Clin Exp Allergy 2001;31:5–7.
15. Hourihane JOB, Kilburn DP, Warner O. Clinical characteristics of peanut allergy. Clin Exp Allergy 1997;27:634–9.
16. Chung SY, Champagne ET. Association of end-product adducts with increased IgE binding of roasted peanuts. Agric Chem 2001;49:3911–6.
17. Beyer K, Morrow E, Li XM, Bardina L, Bannon GA, Burks AW, Sampson HA. Effects of cooking methods on peanut allergenicity. J Allergy Clin Immunol 2001;107:1077–8.
18. Nerquaye-Tetteh GA. Extension of research results to end-users: success stories and failures—the case of the FAO/Food Research Institute chorkor smoker. Accra, Ghana: FAO/Food Research Institute, 1989.
19. Plahar WA, Nerquaye-Tetteh GA, Annan NT. Development of an integrated quality assurance system for the traditional *Sardinella* sp. and anchovy fish smoking industry in Ghana. Food Control 1999;10:15–25.
20. Mulokozi G, Mselle L, Mgoba C, Mugyabuso JKL, Ndossi GD. Reducing subclinical vitamin A deficiency through women's adoption of appropriate technologies in Tanzania. Food Nutr Bull 2001;22:400–7.
21. Hagenimana V, Low J, Anyango M. Enhancing vitamin A intake in young children in Kenya: orange-fleshed sweet potatoes and women farmers can serve as key entry points. Food Nutr Bull 2001;22:376–87.
22. Solomons NW, Bulux J. Identification and production of local carotene-rich foods to combat vitamin A malnutrition. Eur J Clin Nutr 1997;51:S39–45.
23. Borhade VP, Kadam SS, Salunkhe DK. Solubilisation and functional properties of moth bean, marechal and horsegram proteins. J Food Biochem 1984;8:229.
24. Muller HG, Nyarko-Mensah B. Studies on *kenkey*, a Ghanian cereal food. J Sci Food Agric 1972;23:544–5.
25. Amoa B, Muller HG. Studies on *kenkey* with particular reference to calcium and phytic acid. Cereal Chem 1979;53:365–75.
26. Cheryan M. Phytic acid interactions in food systems. Crit Rev Food Sci Nutr 1980;13:297–335.

27. Hotz C, Gibson RS. Assessment of home-based processing methods to reduce the phytate content and phytate/zinc ratio of white maize (*Zea mays*). J Agric Food Chem 2001;49:692–8.

28. Hotz C, Gibson RS, Temple L. A home-based method to reduce phytate content and increase zinc bioavailability in maize-based complementary diets. Int J Food Sci Nutr 2001;52:133–42.

29. O'Dell BL, Burpo CE, Savage JE. Evaluation of zinc availability in foodstuffs of plant and animal origin. J Nutr 1972;102:653–60.

30. Mamiro PRS, Van Camp VJ, Mwikya AM, Huyghebaert A. *In vitro* extractability of calcium, iron and zinc in finger millet and kidney beans during processing. J Food Sci 2001;66:1271–5.

31. Mbithi-Mwikya S, Van Camp J, Mamiro PR, Ooghe W, Kolsteren P, Huyghebaert A. Evaluation of the nutritional characteristics of finger millet-based complementary food. J Agric Food Chem 2002;50:3030–6.

32. Lolas GM, Markakis P. The phytate of navy bean (*Phaseolus vulgaris*). J Food Sci 1977;42:1094–8.

33. Ayyangari R, Rao BSN, Roy DN. Lectins, trypsin inhibitors, BOAA and tannins in legumes and cereals and the effects of processing. Food Chem 1989;34:229–38.

34. Onyango E. Enhancing mineral bioavailability in sorghum using natural fermentation. Gaborone: Uniiversity of Botswana, 2001.

35. Mensah PA. Anti-microbial effect of fermented Ghanaian maize dough. Final report on Project E1945. Stockholm, Sweden: International Foundation for Science, 1995.

36. Steinkraus KH. Classification of fermented foods: worldwide review of household fermentation techniques. Food Control 1997;8:311–7.

37. Mensah P. Microbiological studies of fermented Ghanaian maize dough. London: London School of Hygiene and Tropical Medicine, 1990.

38. Oyewole OB. Lactic fermented foods in Africa and their benefits. Food Control 1997;8:289–97.

39. Svanberg U, Lorri W. Fermentation and nutrient availability. Food Control 1997;8:319–27.

40. Pederson CS. Microbiology of fermentation. Westport, Conn, USA: AVI Publishing Company, 1971.

41. Svanberg U, Lorri W, Sandberg A-S. Lactic fermentation on non-tannin and high-tanin cereals: effects on *in vitro* estimation of iron availability and phytate hydrolysis. J Food Sci 1993;58:408–12.

42. Murdock FA, Fields ML. B-vitamin content of natural lactic acid fermented corn meal. J Food Sci 1984;49:373.

43. Jellife DB. Infant nutrition in the tropics. Geneva: World Health Organization, 1968.

44. Willumsen JF, Darling JC, Kitundu JA, Kingamkono RR, Msengi AE, Mduma B, Sullivan KR, Tomkins AM. Dietary management of acute diarrhoea in children: effect of fermented and amylase-digested weaning foods on intestinal permeability. J Pediatr Gastroenterol Nutr 1997;24:235–41.

45. Adams MR, Nicolaides L. Review of the sensitivity of different foodborne pathogens to fermentation. Food Control 1997;8:227–39.

46. Mensah P. Fermentation—the key to food safety assurance in Africa? Food Control 1997;8:271–8.

47. Tomkins AM, Alnwick D, Haggerty P. Fermented foods for improving child feeding in Eastern and Southern Africa: a review. In: Alnwick D, Moses S, Schmidt OG, eds. Workshop on improving young child feeding in Eastern and Southern Africa: household-level food technology, Nairobi, Kenya. Ottawa: International Development Research Centre, 1987:136–45.

48. Mbugua SK, Njenga J. The anti-microbial activity of fermented *uji*. Ecol Food Nutr 1998;28:191–8.

49. Asiedu M. Antimicrobial effect of fermented maize dough on *Salmonella* spp. and *Vibrio cholerae*. Legon, Accra: University of Ghana, Department of Biochemistry.

50. Mbugua SK. Microbial and biochemical aspects of *uji* (an East African sour cereal porridge) fermentation, and its enhancement through the use of lactic acid bacteria. PhD thesis, Cornell University, Ithaca, NY, USA, 1981.

51. Odugbemi T, Odujirin HT, Akintoye CO, Oyerinoe JPO, Esumeh F. Study on the pH of ogi, a Nigerian fermented weaning food, and its effect on enteropathogenic *Escherichia coli*, *Salmonella typhi* and *Salmonella paratyphi*. J Trop Med Hyg 1991;94:219–23.

52. Jay JM. Anti-microbial properties of diacethyl. Appl Environ Microbiol 1982;44:525–32.

53. Cuk Z, Annan-Prah A, Jane M, Zajc-Sattler J. Yogurt: an unlikely source of *Campylobacter jejuni/coli*. J Appl Bacteriol 1987;63:201–5.

54. Tauxe RB, Holmberg SD, Dodin A, Wells JV, Black PA. Epidemic cholera in Mali: high mortality and multiple routes of transmission in a famine area. Epidemiol Infect 1988;100:279–89.

55. Wood GW, Adams MR. Effects of acidification, bacterial fermentation and temperature on the survival of rotavirus in a model weaning food. J Food Protect 1992;55:52–5.

56. Gourama H, Bullerman LB. Antimycotic and antiaflatoxin effect of lactic acid bacteria: a review. J Food Protect 1995;58:1275–80.

57. Lei V, Amoa-Awua WK, Brimer L. Degradation of cyanogenic glycosides by *Lactobacillus plantarum* strains from spontaneous cassava fermentation and other microorganisms. Int J Food Microbiol 1999;53:169–84.

58. Oke OL. Toxicity of cyanogenic glycosides. Food Chem 1980-81;6:9–40.

59. Kingamkono R. Influence of lactic acid fermentation on enteropathogenic bacteria. Götenberg, Sweden: Department of Food Science, Chalmers University of Technology, 1997.

60. Hasegawa Y, Nakamura Y, Tonogai Y, Tersawa S, Ito Y, Uchiyama M. Determination of ethyl carbamate in various fermented foods by selected ion monitoring. J Food Protect 1990;53:1053.

61. Nout MJR. Fermented foods and food safety. Food Res Int 1994;27:291–8.

62. Mayer AM, Poljakoff-Mayber A. The germination of seeds. Oxford and London: Pergamon Press, 1963.

63. Lay MM-G, Fields ML. Nutritive value of germinated corn and corn fermented after germination. J Food Sci 1981;46:1069–73.

64. Hamad AM, Fields ML. Evaluation of protein quality and available lysine in germinated and fermented cereals. J Food Sci 1979;44:456–9.

65. Taur AT, Pawar VD, Ingle UM. Nutritional improvement of grain sorghum (*Sorghum bicolor* (L.) moench) germination. Indian J Nutr Diet 1984;21:168–73.

66. Wang YD, Fields ML. Feasibility of home fermentation to improve the amino acid balance of cornmeal. J Food Sci 1978;43:1104–5.

67. Seenapa M. Sorghum and millets in East Africa with reference to their use in weaning foods. In: Alnwick, Moses S, Schmidt OG, eds. Workshop on improving young child feeding in Eastern and Southern Africa: household-level food technology, Nairobi, Kenya. Ottawa: International Development Research Centre, 1987:39–54.

68. Mosha AC, Svanberg U. Preparation of weaning foods with high nutrient density using flour of germinated cereals. Food Nutr Bull 1983;5:10–4.

69. Lorri W, Svanberg U. Lactic acid-fermented cereal gruels: viscosity and flour concentration. Int J Food Sci Nutr 1993;44:207–13.

70. Chavan UD, Chavan JK, Kadam SS. Effect of fermentation on soluble proteins and in vitro protein digestibility of sorghum, green gram and sorghum-green gram blends. J Food Sci 1988;53:1574–5.

71. Atwell WA, Hyldon RG, Godfrey PD, Galle EL, Sperber WH, Pedersen DC, Evans WD, Rabe GO. Germinated quinoa flour reduces viscosity of starchy foods. Cereal Chem 1988;65:508–9.

72. Gopaldas T, John C. Evaluation of a controlled 6 months feeding trial on intake by infants and toddlers fed high energy-low bulk gruel versus a high energy-high bulk gruel in addition to their habitual home diet. J Trop Paediatr 1991;38:278–83.

73. Ashworth A, Draper A. The potential of traditional technologies for increasing the energy density of weaning foods (A critical review of existing knowledge with particular reference to malting and fermentation). WHO/CDD/92.4e. Geneva: World Health Organization, 1992.

74. Darling JC, Kitundu JA, Kingamkono RR, Msengi AE, Mduma B, Sullivan KR, Tomkins AM. Improved energy intake using amylase-digested weaning foods in Tanzanian children with acute diarrhoea. J Pediatr Gastroenterol Nutr 1995;21:73–81.

75. Bennet VA, Morales E, Gonzalez J, Peerson JML, de Romana LG, Brown KH. Effect of dietary viscosity and energy density on total daily energy consumption by young Peruvian children. Am J Clin Nutr 1999;70:285–91.

76. Vieu MC, Traore T, Treche S. Effects of energy density and sweetness of gruels on Burkinabe infant energy intakes in free living conditions. Int J Food Sci Nutr 2001;52:213–8.

77. Panasiuk O, Bill DD. Cyanide content of sorghum sprouts. J Food Sci 1984;49:791-3.

78. Dada LO, Dendy DAV. Preliminary study of the effect of various processing techniques on cyanide content of germinated sorghum. Trop Sci 1987;27:101–4.

79. Cliff J, Lundquist P, Martensson J, Rosling H, Sorbo B. Association of high cyanide and low sulphur intake in cassava-induced spastic paraparesis. Lancet 1985;ii:1211–2.

80. Glover DV. Improvement of protein quality in maize. Washington, DC: US Agency for International Development, 1976.

81. Bressani R, Ellias LE. All-vegetable protein mixtures for human feeding. The development of INCAP vegetable mixture 14 based on soybean flour. J Food Sci 1966;31:626–9.

82. Ekpenyong TE, Babatunde L, Oyenuga V. Fortification of maize flour-based diets with blends of cashewnut meal, African locust bean and sesame oil meal. J Sci Food Agric 1977;28:710–6.

83. Sefa-Dede S. An old processing method, a new protein food. Food Nutr Bull 1984;6:77–80.

84. WHO. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: World Health Organization, 1998.

85. Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG. A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micro-nutrient status of Ghanaian infants from 6 to 12 mo of age. Am J Clin Nutr 1999;70:391–404.

86. Guptill KS, Esery SA, Oni GA, Brown KH. Evaluation of a face-to-face weaning food intervention in Kwara State, Nigeria: knowledge, trial and adoption of home-prepared weaning food. Soc Sci Med 1993;36:665–72.

87. Delisle H, Zagré N, Ouedraogo V. Marketing of red palm oil as a food source of vitamin A in Burkina Faso: a pilot project involving women's groups. Food Nutr Bull 2001;22:388–94.

88. Bhandari N, Bahl R, Nayyar B, Khohar P, Rohde JE, Bhan MK. Food supplementation with encouragement to feed it to infants from 4 to 15 months of age has a small impact on weight gain. J Nutr 2001;131:1946–51.

89. Dewey KG. The challenges of promoting optimal infant growth. J Nutr 2001;131:1879–80.

90. Briend A. Highly nutrient-dense spreads: a new approach to delivering multiple micronutrients to high-risk groups. J Nutr 2001;85:S175–9.

91. Adish AA, Esrey SA, Gyorkos TW, Jean-Baptiste J, Rojhani A. Effect of consumption of food in iron cooking pots on iron status and growth of young children: a randomised trial. Lancet 1999;353:712–6.

92. Borigato EVM, Martinez FE. Iron nutritional status is improved in Brazilian preterm infants fed food cooked in iron pots. J Nutr 1998;12:855–9.

93. Mensah P. Persistent diarrhoea in Ghana: incidence, aetiology and associations. Accra, Ghana: Noguchi Memorial Institute for Medical Research and Japan International Cooperation Agency, 1997.

94. Kimmons JE, Brown KH, Lartey A, Collison E, Mensah PPA, Dewey KG. The effects of fermentation and/or vacuum flask storage on the presence of coliforms in complementary foods prepared for Ghanaian children. Int J Food Sci Nutr 1999;50:195–201.

95. Simoons FJ. The determinants of dairying and milk use in the Old World: ecological, physiological and cultural. New York: Gordon & Breach, 1980.

96. Mensah P, Armar-Klemesu M, Yeboah-Manu D, Ablordey A, Rikimaru K, Taniguci K, Nkrumah F, Kamiya H. Microbial quality of infant foods from peri-urban Ghana. Afr J Health Sci 1995;2:277–81.

97. Mensah P, Owusu-Darko K, Yeboah-Manu D, Ablordey A, Nkrumah FK, Kamiya H. The role of street food vendors in the transmission of enteric pathogens. Ghana Med J 1999;33:19–29.

98. Mensah P, Yeboah-Manu D, Owusu-Darko K, Ablordey A. Street foods in Accra: How safe are they? WHO Bull 2002;80:546–54.

99. Ehiri JE, Azubuike MC, Ubbaonu CN, Anyanwu EC, Ibe KM, Ogbonna MO. Critical control points of com-

plementary food preparation and handling in eastern Nigeria. WHO Bull 2001;79:423–35.

100. Olukoya DK, Bakare SB, Abayomi O. Microbiological evaluation of food samples sold to primary school children in Lagos, Nigeria. J Trop Pediatr 1991;37:266.

101. Lim-Quizon MC, Benabaye RM, White FM, Dayrit MM, White ME. Cholera in metropolitan Manila: foodborne transmission via street vendors. WHO Bull 1994;72:745–9.

102. El-Sherbeeny MR, Saddik MF, Bryan FL. Microbiological profile of foods served by street vendors in Egypt. Int J Food Microbiol 1985;2:355–64.

103. Draper A. Street foods in developing countries: the potential for micronutrient fortification. London: London School of Hygiene and Tropical Medicine, 1996.

104. Kurz MK, Johnson-Welch C. Enhancing women's contributions to improving family food consumption and nutrition. Food Nutr Bull 2001;22:443–53.

Conclusions of the Global Consultation on Complementary Feeding

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Infants and young children are at increased risk of developing malnutrition from six months of age onwards, when breastmilk alone is no longer sufficient to meet all nutritional requirements and complementary feeding needs to be started. Complementary foods are often of lesser nutritional quality than breastmilk. In addition, they are often given in insufficient amounts, and if given too early or too frequently, they displace breastmilk. Gastric capacity limits the amount of food that a young child can consume during each meal. Repeated infections reduce the appetite and increase the risk of inadequate intakes. Infants and young children need a caring adult who not only selects and offers appropriate foods but also assists and encourages them to consume these foods in sufficient quantity.

Based on the information presented in the five background papers and presentation of additional data from research and programmes to improve complementary feeding, participants in the consultation formulated recommendations to improve complementary feeding, focusing on appropriate feeding practices as well as programmatic approaches for their promotion (box 1).

Meeting energy and nutrient requirements

The Consultation revised feeding recommendations presented in the World Health Organization (WHO)/ UNICEF scientific review on complementary feeding published in 1998 [1] on the basis of new data on energy and nutrient requirements.

The estimated energy requirements from complementary foods, assuming an average breastmilk intake, are now 200 kcal/day for infants aged 6 to 8 months, 300 kcal/day for infants aged 9 to 11 months, and 550 kcal/day for children aged 12 to 23 months.

No major changes were proposed for the estimated nutrient requirements from complementary foods, since the scientific and empirical evidence is not yet sufficiently robust to justify change. However, the data show that some nutrients, notably iron, zinc, and vitamin B_6, are consistently deficient in the diet of infants and young children in most populations in low-income countries. Special attention needs to be paid to the adequacy of these nutrients in the child's diet.

For this age group, adequate energy and nutrient intakes are the result of a balance between appropriate breastfeeding and complementary feeding. Increasing the frequency of complementary feeding, for example, may impair breastmilk intake, with the potential risk of reducing total energy and nutrient intake if no attention is paid to sustaining breastfeeding.

Assuming a diet with energy density of 0.8 kcal/g and low breastmilk intake, the Consultation recommended that infants aged 6 to 8 months be given two or three meals per day, that infants aged 9 to 11 months be given three or four meals per day, and that children aged 12 to 24 months be given three or four meals per day, with the addition of one or two nutritious snacks.

Making adequate complementary foods available

Access to adequate complementary foods is a necessary condition for improved feeding. Programmes to improve complementary feeding should include approaches for improving access to adequate foods, employing the least demanding resources for their purchase and preparation. They can include technologies that can be applied in the home or community, or larger-scale industrial production of processed and fortified foods.

Household technologies such as fermentation, roasting, and malting have been traditionally used in many societies. They can contribute to improving the safety or quality of complementary foods. However, reaching an adequate nutrient level remains a concern, particularly with mainly plant-based diets. Specific additional measures may be needed to enrich complementary foods. Mixing micronutrient sprinkles or nutrient-rich pastes with the food has been successfully promoted in some settings and warrants further exploration. Regular supplementation with micronutrient drops or capsules is another option to fill certain dietary gaps.

BOX 1. Guiding principles for complementary feeding of the breastfed child

1. *Duration of exclusive breastfeeding and age of introduction of complementary foods*
Practice exclusive breastfeeding from birth to six months of age, and introduce complementary foods at six months of age (180 days) while continuing to breastfeed.

2. *Maintenance of breastfeeding*
Continue frequent, on-demand breastfeeding until two years of age or beyond.

3. *Responsive feeding*
Practice responsive feeding, applying the principles of psychosocial care. Specifically: a) feed infants directly and assist older children when they feed themselves, being sensitive to their hunger and satiety cues; b) feed slowly and patiently, and encourage children to eat, but do not force them; c) if children refuse many foods, experiment with different food combinations, tastes, textures, and methods of encouragement; e) minimize distractions during meals if the child loses interest easily; f) remember that feeding times are periods of learning and love—talk to children during feeding, with eye-to-eye contact.

4. *Safe preparation and storage of complementary foods*
Practice good hygiene and proper food handling by a) washing caregivers' and children's hands before food preparation and eating, b) storing foods safely and serving foods immediately after preparation, c) using clean utensils to prepare and serve food, d) using clean cups and bowls when feeding children, and e) avoiding the use of feeding bottles, which are difficult to keep clean.

5. *Amount of complementary food needed*
Start at six months of age with small amounts of food and increase the quantity as the child gets older, while maintaining frequent breastfeeding. The energy needs from complementary foods for infants with "average" breastmilk intake in developing countries are approximately 200 kcal per day at 6 to 8 months of age, 300 kcal per day at 9 to 11 months of age, and 550 kcal per day at 12 to 23 months of age. In industrialized countries these estimates differ somewhat (130, 310, and 580 kcal/day at 6–8, 9–11, and 12–23 months, respectively) because of differences in average breastmilk intake.

6. *Food consistency*
Gradually increase food consistency and variety as the infant gets older, adapting to the infant's requirements and abilities. Infants can eat pureed, mashed, and semisolid foods beginning at six months. By eight months most infants can also eat "finger foods" (snacks that can be eaten by children alone). By 12 months, most children can eat the same types of foods as those consumed by the rest of the family (keeping in mind the need for nutrient-dense foods, as explained in no. 8 below). Avoid foods that may cause choking (i.e., items that have a shape and/or consistency that may cause them to become lodged in the trachea, such as nuts, grapes, and raw carrots).

7. *Meal frequency and energy density*
Increase the number of times that the child is fed complementary foods as he or she gets older. The appropriate number of feedings depends on the energy density of the local foods and the usual amounts consumed at each feeding. For the average healthy breastfed infant, meals of complementary foods should be provided two or three times per day at 6 to 8 months of age, three or four times per day at 9 to 11 months, and three or four times per day at 12 to 24 months, with additional nutritious snacks (such as a piece of fruit or bread or chapatti with nut paste) offered one or two times per day, as desired. Snacks are defined as foods eaten between meals—usually self-fed, convenient, and easy to prepare. If the energy density or amount of food per meal is low, or the child is no longer breastfed, more frequent meals may be required.

8. *Nutrient content of complementary foods*
Feed a variety of foods to ensure that nutrient needs are met. Meat, poultry, fish, or eggs should be eaten daily, or as often as possible. Vegetarian diets cannot meet nutrient needs at this age unless nutrient supplements or fortified products are used (see no. 9 below). Vitamin A–rich fruits and vegetables should be eaten daily. Provide diets with adequate fat content. Avoid giving drinks with low nutrient value, such as tea, coffee, and sugary drinks such as soda. Limit the amount of juice offered so as to avoid displacing more nutrient-rich foods.

9. *Use of vitamin-mineral supplements or fortified products for infant and mother*
Use fortified complementary foods or vitamin-mineral supplements for the infant, as needed. In some populations, breastfeeding mothers may also need vitamin-mineral supplements or fortified products, both for their own health and to ensure normal concentrations of certain nutrients (particularly vitamins) in their breastmilk. (Such products may also be beneficial for prepregnant and pregnant women.)

10. *Feeding during and after illness*
Increase fluid intake during illness, including more frequent breastfeeding, and encourage the child to eat soft, varied, appetizing, favorite foods. After illness, give food more often than usual and encourage the child to eat more.

From: Pan American Health Organization, Guiding Principles for Complementary Feeding of the Breastfed Child. Pan American Health Organization, World Health Organization. Washington DC, 2002.

Centrally processed and fortified foods can also play an important role in ensuring adequacy of diets. Rapid urbanization and changing social networks will increasingly affect caregivers' ability to use freshly prepared home-grown foods. The challenge will be to ensure central production of high-quality complementary foods, while maintaining ethical and quality standards for production, marketing, and distribution, in accordance with the International Code of Marketing of Breast-Milk Substitutes, subsequent relevant World Health Assembly resolutions, and the Codex Alimentarius.

Improving feeding practices

Improving complementary feeding practices requires attention to foods as well as to the feeding behaviors of caregivers. Infants and young children need assistance that is appropriate for their age and developmental needs to ensure that they consume adequate amounts of complementary food. This is called responsive feeding.

Inappropriate feeding behaviors are an important determinant of malnutrition. Caregivers often are not aware of the importance of, or do not know how to practice, responsive feeding. They need support from health professionals or community-based workers to acquire the necessary knowledge and skills.

The safety of behaviors related to the preparation, feeding, and storage of complementary foods is also an important factor to address in interventions to improve complementary feeding, since contamination and the proliferation of pathogens in food is a major cause of childhood diarrhea.

Feeding behaviors are anchored in a wider belief system that influences what, when, where, and how people feed. To be most effective, interventions to improve infant feeding should be based on an in-depth assessment of this system, address major barriers, and use existing channels and resources to support behavior change.

Current knowledge emphasizes the importance of involving families rather than individual caregivers in designing interventions. Assessing time allocation and time constraints in relation to food preparation and feeding is also critical, as well as estimating the real costs associated with implementing new feeding recommendations.

Strengthening programmatic approaches to improve complementary feeding

In spite of the critical importance of appropriate complementary feeding for child growth and development, interventions to improve feeding practices in children

6 to 24 months of age have received insufficient attention. The Global Strategy for Infant and Young Child Feeding [2] provides a framework for action and calls for concerted efforts to improve complementary feeding, together with support for sustained breastfeeding. Its operational targets stimulate governments and all concerned parties to take the following actions, among others:

» Adopt a comprehensive national policy on infant and young child feeding, in the context of national policies and programs for nutrition, child and reproductive health, and related areas;

» Constitute a national body to lead the implementation of the strategy as a coordinated national response;

» Ensure that the health and other sectors are able to protect, promote, and support appropriate infant and young child feeding practices, including those for children in exceptionally difficult circumstances;

» Consider new legislation and other suitable measures to give effect to the principles and aim of the International Code of Marketing of Breast-Milk Substitutes and subsequent World Health Assembly resolutions; and

» Enact imaginative legislation protecting the breastfeeding rights of working women.

The Consultation emphasized the importance of fulfilling these operational targets to make sustainable progress. Rather than calling for a separate initiative, they recommended the integration of effective interventions to improve complementary feeding into existing programmes and initiatives.

Evidence shows that that feeding counseling by health professionals or community-based workers is an important intervention that can lead to considerable improvements in infant and young child feeding practices. The Consultation recognized that there were many opportunities in the health sector for providing feeding counseling. Integrated Management of Childhood Illness (IMCI) was highlighted as an important strategy that has successfully integrated feeding counseling in guidelines for the management and prevention of common childhood illnesses. This strategy is being implemented in over 80 countries.

The Consultation endorsed a set of guiding principles for complementary feeding of the breastfed child prepared by Dr. Kathryn Dewey on behalf of the Pan American Health Organization as a basis for developing locally appropriate feeding recommendations [3]. Their implementation will require adaptation to local contexts with the specification of the foods that are acceptable and affordable for families, using feasible strategies to ensure their availability, and to address barriers in current feeding behaviors, including food preparation and storage practices.

Efforts to increase investments in the promotion of improved infant and young child feeding require

adequate monitoring and evaluation. Although a global set of indicators to measure breastfeeding practices was agreed on a decade ago and has since been used successfully to assess progress, the indicators for measuring complementary feeding practices are scant. To guide program action, there is need to develop a set of indicators that cover the entire range of infant and young child feeding practices, including appropriate complementary feeding.

Research priorities

Although the evidence base for moving forward rapidly with programmatic actions is sound, further research is needed to broaden and refine the range of strategies and interventions. The Consultation identified the following priority areas for research:

» Estimating energy and nutrient requirements of children living in especially vulnerable circumstances, such as infants of HIV-positive mothers who chose not to breastfeed, preterm infants, and low-birth-weight infants.
» Assessing the effects of variations in energy density, feeding frequency, food quantity, and food variety on total energy intake, including the intake of breastmilk;
» Identifying factors affecting children's appetite and appropriate treatment of anorexia;
» Determining the optimal amount and type of lipid and fiber intake by children;
» Examining the use of linear programming for developing context-specific complementary feeding guidelines;
» Identifying alternative approaches to create demand for affordable and effective processed food products;
» Assessing the efficacy and effectiveness of fortified complementary foods, sprinkles, and spreads in addressing dietary gaps, including optimal levels of formulations and ration sizes to improve nutrient intakes;

» Determining the bioavailability of iron and zinc in locally available foods;
» Determining methods and criteria for characterizing the responsiveness of feeding styles in various settings and identifying effective methods for promoting responsive feeding;
» Determining the impact of improved responsive feeding on child growth and developmental outcomes;
» Developing and testing appropriate and effective strategies to ensure the safe storage, preparation, and feeding of complementary foods to infants and young children;
» Developing strategies for maintaining and sustaining breastfeeding as complementary foods are introduced and the young child progresses to the family diet;
» Developing and testing indicators and tools for designing, implementing, and evaluating programs promoting appropriate infant and young child feeding.

Conclusions

Improvement of complementary feeding has received insufficient attention as a public health intervention. Given the important consequences of early childhood malnutrition for health and development, there is an urgent need to act. Effective interventions are available, and the evidence for improving existing guidelines and programmatic actions is rapidly expanding. Although research will be important to answer unresolved issues and respond to new challenges, implementation of existing interventions should be accelerated. Internationally agreed goals for the reduction of malnutrition and child mortality will be achieved only if families can receive the support they need to adequately care for their children's nutritional needs, thus contributing to improved survival, growth, and development.

References

1. Complementary feeding of young children in developing countries: a review of current scientific knowledge (WHO/NUT/98.1). Geneva: World Health Organization, 1998.
2. Global strategy for infant and young child feeding (WHA 55/2002/REC/1, Annex 2). Geneva: World Health Assembly, 2002.

3. Pan American Health Organization. Guiding principles for complementary feeding of the breastfed child. Washington, DC: Pan American Health Organization and World Health Organization, 2002.

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Foodborne disease: A focus for health education. World Health Organization, Geneva, 2000. (ISBN 92-4-156196-3) 198 pages, paperback. Sw Fr 62, US$55.80. Sw Fr 43.40 in developing countries.

This book provides a guide to the education of food handlers and consumers as an effective strategy for reducing the enormous illness and economic losses caused by food-borne disease. Addressed to policy makers as well as food safety managers in the public and private sectors, the book responds to mounting concern over the increase in the incidence of food-borne disease, including outbreaks caused by new or newly recognized pathogens. With this concern in mind, the book presents the facts, figures, and practical examples needed to understand both the links between food and disease and the many reasons why health education is one of the best approaches to prevention.

The book has five chapters. The first and most extensive chapter provides a detailed explanation of the nature of food-borne diseases, global trends in their occurrence, health consequences, economic implications, reasons for the emergence of new pathogens, and factors affecting prevalence. The distinct problems of industrialized and developing countries are considered separately. Chapter 2, on health education, gives 10 reasons why health education in food safety is both necessary and effective. Of the three lines of defense, which include improvement of the hygienic quality of the raw foodstuffs and use of food processing technologies to control contaminants, health education and training are singled out as the most important options for prevention. The chapter also uses experiences from industrialized and developing countries to show why a comprehensive and well-funded regulatory system alone cannot prevent food-borne disease.

Against this background, Chapter 3 addresses the complexity of behaviors that affect food safety and describes a range of scientific approaches that have been used to target specific behaviors for change. The remaining chapters use initiatives from several countries to suggest strategies and partners for edu-cational programs, and offer guidance on the practical design, planning, and implementation of educational programs.

Of particular value is a 46-page annex that sets out, in tabular form, key information for 31 food-borne diseases caused by bacteria, viruses, and parasites. Each disease is profiled in terms of its causative agent, incubation period, symptoms and sequelae, duration of illness, source or reservoir of the etiological agent, mode of transmission, frequently implicated foods, and specific control measures appropriate for food service establishments and consumers. The book concludes with a guide to effective risk communication aimed at mitigating pubic concern about food safety issues.

Handbook of dietary fiber. Edited by Susan Sungsoo Cho and Mark L. Dreher. Marcel Dekker, New York, 2001. (ISBN 0-8247-8960-1) 868 pages, hardcover. US$225.00

There has been growing appreciation of the importance of dietary fiber in the maintenance of health, including reducing the risk of certain types of cancer. This book examines comprehensively and authoritatively the evidence for this. The relationship of dietary fiber to cardiovascular disease, colon cancer, breast cancer, prostate cancer, and diabetes is reviewed in separate chapters. These are followed by six chapters dealing with various categories of physiochemical properties and four dealing with chemical and analytical procedures relevant to dietary fiber. A fourth section of the book offers 15 chapters dealing with the functional properties of individual fiber-containing foods. The final chapters depart from the comprehensive review theme of the book and report on the use of fiber-containing foods in seven countries: Brazil, Chile, China, Mexico, Israel, Poland, and Spain. While illustrative, a chapter generalizing to other countries would have been welcome. Seventy-four authors from 23 countries contributed, but there is little overlap and the coverage of the basic issues is remarkably extensive. This is

a handbook and not a textbook. As such it will be a unique reference source for the developers of new food products, health educators, researchers, and others with a special interest in this subject.

Keep fit for life: Meeting the nutritional needs of older persons. World Health Organization, Geneva, 2002. (ISBN 92-4-156210-2) 119 pages, paperback. Sw Fr 30, US$27.00. Sw Fr 21- in developing countries.

The World Health Organization (WHO) promotes the attainment of the highest possible level of health and quality of life for persons of all ages, including the elderly. The Human Nutrition Research Center on Aging at Tufts University in Boston is an outstanding academic center for studies of healthy aging. This volume represents a collaborative consultation meeting to review the scientific evidence linking diet and other factors, especially exercise, affecting nutritional status and the maintenance of health. It begins with explicit recommendations for improving the heath and nutritional status of older persons in a wide variety of socioeconomic issues. It then deals with the epidemiological and social aspects of aging, including the influence of nutrition on chronic degenerative diseases.

It deals realistically with the functional changes associated with aging, but it also emphasizes the extent to which these changes can be slowed and even reversed by good diet and exercise that includes strength training, which the Tufts Center has pioneered. It explains the functions of the individual nutrients and the importance of ensuring their adequate intake by the elderly. An annex provides food-based dietary guidelines for older adults. In a concise and readable way, this small paperback provides sound and practical advice to all health professionals concerned with maintaining and improving the health of the elderly. It will also be an authoritative guide on this subject for science writers and schoolteachers. It is affordable and highly recommended as an up-to-date replacement for earlier publications on nutrition, health, and aging.

The nutrition transition: Diet and disease in the developing world. Edited by Benjamin Caballero and Barry M. Popkin. Academic Press, London and San Diego, 2002. (ISBN-0-12-153654-8) 261 pages, hardcover. £55.00.

The transitions described in this book have few precedents in both the rapidity of the changes and the large proportion of the world's population involved. The shift from hunting and gathering to agriculture was spread over thousands of years and the industrial revolution over about 200 years, but transitions are now occurring within developing countries over a few

decades. They are determining the future health and welfare of humankind and the nature of the environment in which we all must live. This book contains informative descriptions of past changes and trends, but its importance lies in its characterization of dynamic current processes and their probable impact on future history.

As recently as the 1960s, cases of severe protein–calorie malnutrition, kwashiorkor, could still be demonstrated in children in almost any hospital in the developing world. Only 20 years later, kwashiorkor had essentially disappeared. Earlier this occurred for scurvy, pellagra, and beri-beri. In the 1930s, pellagra was still a major problem in the United States. Beri-beri persisted in Southeast Asia into the 1950s. The ocular signs of vitamin A deficiency leading to blindness were still a serious concern in the 1970s but are now rare, even in poor countries. Except for scurvy, which largely disappeared earlier, these transitions occurred in the twentieth century, although these nutritional disorders have returned in some refugee populations.

Thirty years ago obesity was rare, particularly in developing countries. It is now increasing rapidly in both industrialized and developing countries, with seriously adverse impacts on health. A characteristic of these successive transitions is that they are coming more frequently, are progressing more rapidly, and are increasingly global in scope. This book documents and interprets the current transition that is occurring in both nutrition and related socioeconomic conditions in developing nations. They are associated with a demographic transition in an increasing number of these countries.

The nutrition transition is taking place so rapidly that undernutrition and micronutrient deficiencies coexist with overnutrition. As a consequence, many developing countries still face the need to prevent undernutrition and malnutrition at a time when they are facing an increasing burden of chronic degenerative disease.

The dynamics of the current dietary change and the increasing obesity and diabetes in the developing world are well described in early chapters. The decrease in physical activity and its consequences is so important that it has its own chapter. So does a relatively new theme, the relationship between early malnutrition and the later occurrence of chronic degenerative disease. Low birthweight, due largely to poor nutrition during pregnancy and malnutrition during infancy, has been shown to increase the risk of diabetes, hypertension, and coronary heart disease in later life. Populations with a relatively high frequency of fetal and infant malnutrition whose rising affluence leads them to consume more dietary fat and exercise less appear to be at a particularly high risk of chronic disease as they age. This is a further burden on developing countries in transition.

Other important topics covered are the roles of governance, globalization, demographic behavior, and disease trends. China and Brazil are presented as case studies of what may be happening or will happen with regard to diet, activity levels, and health in other parts of the developing world. The chapter on food wisely avoids predictions of global food shortages but does express concern that the developing world may not be able to derive the full benefit from current and future scientific and technical advances in food production,

This book is a valuable documentation of the food and nutrition components of the most accelerated set of major transitions in human history. Readers will find it a fascinating and insightful glimpse into the benefits and threats to health of the unprecedented nutrition, demographic, and economic changes that are so strongly and rapidly affecting the health and welfare of the populations of developing countries.

Nevin S. Scrimshaw

News and notes

Training in Public Nutrition at Emory University

The Department of International Health of Emory University now offers an MSPH degree in Public Nutrition. This new two-year program of study provides a comprehensive understanding of major nutrition problems afflicting people in both wealthy and poor nations, as well as the policies and programs to address them. The program is distinguished by an emphasis on methods, especially nutrition assessment, epidemiology, biostatistics, research design and survey methods, program design, monitoring and evaluation, and policy analysis. Opportunities and funding for summer fieldwork anywhere in the world are available to students on a competitive basis. For additional details, including financial aid, interested applicants are encouraged to visit our web site (http://www.sph.emory.edu/hpdih.html) or write to MSPH Degree, Department of International Health, Rollins School of Public Health, Emory University, 1518 Clifton Road, N.E., Atlanta, GA 30322, USA.

Arbor Clinical Nutrition Updates: Invitation

Arbor Clinical Nutrition Updates is a free weekly publication that provides a brief summary of the latest nutrition research and what it means to practicing clinicians. The Updates are sent by e-mail without cost as a public health service to health professionals with an interest in nutrition. The Updates are the world's most widely read electronic nutrition publication for health professionals, with more than 75,000 readers in 171 countries. There is a distinguished editorial board made up of many of the world's leading nutrition experts. A full listing is available at http://arborcom.com/updates/board.htm. The Updates were recently featured in the *Lancet* (2000;355:1109). They are published in eight languages (English, Spanish, Portuguese, French, Italian, Russian, Korean, and Japanese). If you would like to receive this free service, you must register and complete an information form.

This is a valuable service, and readers of the *Bulletin* are encouraged to take advantage of it by specifying the topics on which they wish to be updated.

Increase in Subsidized Subscriptions for the *Food and Nutrition Bulletin*

The *Food and Nutrition Bulletin* is the most widely distributed nutrition journal in developing countries because support from the United Nations University (UNU) has made it possible to provide a large number of subscriptions to developing country institutions and scientists without charge. However, the request for such subscriptions has far exceeded the funds available for the purpose. In recent years UNICEF has been providing the *Bulletin* without charge to its field offices and nutrition-related personnel. In the current year the International Atomic Energy Agency (IAEA) and the International Life Science Institute/United States Agency for International Development (ILSI/USAID) have agreed to provide additional complimentary copies, as have the firms of Heinz, Kellogg, Kraft Foods, Nestlé, Procter & Gamble, and Roche Vitamins. Other contributions are pending. Contributors will be acknowledged with appreciation in all future issues.

This new funding, complementing that provided by UNU, will make it possible to increase significantly the subsidized copies of the *Bulletin* available to institutions and nutrition-related professionals in developing countries beginning with the June 2003 issue.

We invite eligible institutions and individuals to contact the Managing Editor to apply for a subsidized subscription. The number of subsidized subscriptions available will depend on the additional support obtained.

One reason it is possible to obtain this support is not only the *Bulletin*'s penetration of distribution into developing countries, but also the high proportion of manuscripts submitted by developing country authors. We particularly encourage contributions from these authors.

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International Center for Diarrheal Disease Research (ICDDR, B), Dhaka, Bangladesh
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    World Food Programme (WFP)
    World Health Organization (WHO)
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2. Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36:119–25.

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3. Brozek J. Malnutrition and human behavior: experimental, clinical and community studies. New York: Van Nostrand Reinhold, 1985.
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4. American Medical Association, Department of Drugs. AMA drug evaluations, 3rd ed. Littleton, Mass, USA: Publishing Sciences Group, 1977.
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