Editorial

Complementary Feeding of Infants and Young Children

According to recent statistics, the rates of childhood malnutrition in India are among the highest in the world(1). Approximately 52% of children less than five years of age are nutritionally stunted (low height-for-age; <–2 SD with respect to international reference data), 18% are wasted (low weight-for-height), and 53% are underweight (low weight for age). These figures are indicative of a severe public health problem(2). The fact that nearly 30% of babies born in India are of low birth weight(3,4) may explain some, but obviously not all, of the high rates of malnutrition that are observed later in life(5). Growth faltering continues post-natally, especially during the period when children should be receiving other foods (*i.e.*, complementary foods) in addition to breast milk.

Complementary foods can be defined as any non-breast milk foods or nutritive liquids given to young children during the period of breastfeeding. The World Health Organization and UNICEF have recently published extensive guidelines on appropriate complementary feeding(6), which make this an opportune time to review child-feeding issues in India, with particular focus on: (*i*) the appropriate time of introduction of complementary foods; (*ii*) the amounts of energy required from these foods by children of different ages; (*iii*) the appropriate energy density and frequency of feeding complementary foods; and (*iv*) their appropriate macro- and micronutrient densities.

The optimal age of introduction of complementary foods is controversial because of the so-called "weanling's dilemma"(7) whereby delayed initiation of these foods may result in low energy and nutrient intakes and consequent malnutrition, while premature introduction of these foods is often accompanied by increased morbidity and mortality from infections(8-10). The World Health Organization currently recommends exclusive breast feeding for four to six months(11), although UNICEF states that complementary feeding should be initiated "at about six months"(12). Because of the considerably increased risk of infection associated with consumption of these foods, a two-month difference in the timing of their introduction could have important implications for global rates of diarrhea and other illnesses. Seven prospective studies carried out in six low-income countries in Africa, Asia, and Latin America provide relevant information on the relationship between infant feeding mode and growth velocity during the period from four to six months of age(13-19). In none of these studies was growth enhanced when complementary foods were introduced prior to six months. To contrary, in three studies (two in Sudan, one in Indonesia) children who first received complementary foods after six months had greater growth increments during the preceding two-month interval. These results therefore suggest that complementary foods should not be introduced before six months.

Because the aforementioned observational studies are subject to self-selection bias, randomized intervention trials are also needed to draw definitive conclusions regarding causal relationships between feeding practices and infant growth. Notably, a trial recently completed in Honduras to examine this issue found that the levels of total energy intake and rates of physical growth were similar among infants who were randomly assigned to either continue breastfeeding exclusively until six months of age or begin receiving high quality, hygienically packaged complementary foods at four months(20). Thus, there was no advantage of introducing complementary foods prior to six months of age. Similar results have now been reported from a second study restricted to low birth weight Honduran infants(21). Additional studies in South Asia, and perhaps other regions of the world, would be useful to confirm this conclusion in populations where maternal malnutrition is more common.

Once complementary toods are introduced, the amount of these foods that should be provided depends on children's total energy and nutrient requirements at different ages and the corresponding amounts of these provided by breast milk. Information on energy consumption from breast milk was recently compiled from 21 published studies conducted in developing countries(6). Mean breast milk energy intakes reported from these studies were 413, 379, and 346 kcal/d by children 6-8, 9-11, and 12-23 months of age, respectively. Current estimates of children's average energy needs are 682, 830, and 1092 kcal/d for these same age groups(22,23). Thus, the respective age-specific average (rounded) amounts of energy required from complementary foods are approximately 275, 450 and 750 kcal/d.

Because of the known inter-individual variability in both energy requirements and energy intake from breast milk, the foregoing figures are, of course, crude estimates of the true amounts of energy needed from complementary foods by individual children. Nevertheless, these mean values provide useful guidelines for designing programs to promote appropriate complementary feeding. Depending on their appetite and physical growth, individual children may need more or less than these theoretical average amounts.

To ensure that children are physically able to consume the recommended daily quantity of energy from complementary foods, the minimum energy density and frequency of feeding of these foods must be appropriate for age. Results of recently published studies of the effects of three different meal frequencies and four energy densities on total daily energy intakes by fully weaned, recovering malnourished children between 6-18 months of age indicate that both energy density and meal frequency are significant determinants, of total energy intake(24). Controlling for the level of energy density, the total daily amount of food consumed during these studies increased by approximately 16% when four meals were provided per day. However, the total amount of time required for feeding also increased in direct relation to the number of meals. This additional time factor may constrain greater meal frequency, especially when caregivers have multiple competing responsibilities, including other child care tasks.

These foregoing studies also examined the effects of varied energy densities on the children's total energy intake. The energy densities of the different diets were 0.4, 0.7, 1.0, or 1.5 kcal/g. Controlling for the frequency of feeding, the total daily energy intakes (kcal/kg/d) increased significantly when the children consumed the diets with greater energy density, and there were no significant interactions between energy density and feeding frequency. In other words, greater energy intakes occurred with each added meal, regardless of the energy density of the diet; and the energy intakes increased with each higher level of energy density, regardless of the meal frequencies.

Estimates of the appropriate energy density and frequency of feeding of complementary foods have been developed, using data from two studies on the amount of food that fully weaned children were able to consume at a single meal(24,25) and the previously described estimates of the amount of energy required form complementary foods by breastfed children(6). In the two studies of children's food intake, almost all children were able to consume at least 30 g/kg body weight at a single meal. These figures for so-called "functional gastric capacity" were combined with published information on average body weights of children at different ages to estimate the amount of food that could likely be consumed at a single meal during different age ranges. Assuming that the median weight of a well nourished reference child is 8.3 kg at 7 months, 9.5 kg at 10 months, and 11.5 kg at 18 months (26), the amounts that could be consumed at a single meal are 249 g, 285 g, and 345 g for the respective ages. Using these figures for the amount of food that can be consumed at a single meal and different assumptions of two, three, or four meals per day in addition to breastfeeding, it is possible to calculate the minimum average energy density would be required for these meals to be able to provide the energy needed from complementary foods at different ages, as follows.

To provide a conservative estimate of energy that would be required from complementary foods to satisfy the total energy needs of almost all children in a population of a particular age range, the average energy requirement plus 2SD (that is, the mean plus 25%) was used. The energy consumed from breast milk by children consuming low, average, or high amounts of breast milk was subtracted from the figure for the total energy requirements, (mean plus 2 SD) to estimate the amount of energy needed from complementary foods. For example, infants from six to eight months of age–who potentially need as much as 852 kcal/d (mean +2 SD) and receive an average amount of breast milk energy (413 kcal/d)–would need a total of up to 439 kcal per day from complementary foods. If they consume two meals per day of 249 g, the energy density of those meals would have to be at least 0.88 kcal/g to ensure that the upper range of total energy intake could be consumed.

Detailed estimates of the minimal levels of energy density of complementary foods that are theoretically adequate for children of different ages are available in the recent WHO publication(6). Because the estimates are derived from a limited amount of empirical data, they must be interpreted with great caution. Nevertheless, they provide a useful starting point for developing tentative guidelines for child feeding programs. The published estimates, which consider a range of meal frequencies and different levels of assumed breast milk consumption, indicate, for example, that well nourished breastfed infants from six to eight months of age who consume three meals per day should receive complementary foods with an energy density of at least 0.85 kcal/g if they consume a low-level of energy from breast milk. Children consuming greater amounts of energy from breast milk could receive either fewer meals or foods with correspondingly lower levels of energy density. As children get older, they need either increasingly greater levels of energy density or feeding frequency or some combination of the two.

Sensory properties of complementary foods, such as flavor, aroma, and consistency, and overall diversity of the diet can independently affect total intake. Pioneering studies in India have found, for example, that amylase treatment of starch-containing porridges reduces their viscosity, thereby permitting greater energy and nutrient densities while assuring that the preparations are thin enough for easy consumption by young children(27). Most, but not all, studies of amylase liquefaction of thick porridges have found that children's total energy intakes increased when foods were treated in this way(6).

The protein density (g/kcal) of complementary food is likely to be a limiting factor in most populations, although this generalization may not hold in settings where complementary foods are based on staples of very low protein content, such as cassava or sweet potatoes. Amino acid requirements from complementary foods were not considered in the WHO report, but should be reviewed in the future. Breast milk of well nourished mothers should meet the essential fatty acid (EFA) requirements of exclusively breastfed infants, but there is little information on the ability of current complementary feeding regimens to satisfy EFA requirements after the period of exclusive breastfeeding. Thus, care should be taken to assure that complementary foods contain enough EFA to meet requirements and enough total fat to facilitate absorption of fat soluble vitamins from complementary foods. The desirable fat content of complementary foods depends on the mother's breast milk fat concentration, the infant's intake of breast milk, and the judgement of what is an acceptable percentage of total energy from fat. Assuming that approximately 30% of total energy intake from fat is desirable, complementary foods should contain on average approximately 0-13% of energy from fat at 6-11 months and 21% of energy from fat at 12-23 months(6).

Meeting micronutrient needs from complementary foods appears to be the greatest challenge. As with energy, the estimates of the amounts of micronutrients required from complementary foods are based on the age-specific nutrient requirements less the presumed amounts provided by breast milk. Based on these calculations, which are presented in detail in the WHO report(6), adequate amounts of certain key nutrients (iron, zinc, and calcium, in particular) can only be met if animal products are consumed in sizeable quantities–levels of intake that are unlikely to be feasible in non-meat-eating communities and poor households. Thus, alternative strategies, such as fortification or supplementation, may need to be considered.

For children whose mothers have adequate breast milk vitamin A concentrations (at least 50 μg/L), vitamin A needs can be readily met by appropriate selection of complementary foods. Good food sources of vitamin A include liver, milk, eggs, cheese, yellow-orange fruits, leafy green vegetables, and tomatoes, although the bioavailability of vitamin A from plant sources has been questioned(28). For infants aged 6-11 months, the amounts required of these foods are not large (generally 1-50 g/d), in part because breast milk is a rich source of the vitamin. In areas where vitamin A deficiency is endemic, as is the case in much of India(29), increased vitamin A intake by the mothers and/or greater intakes of vitamin A-rich complementary foods by children is advisable. Vitamin A supplementation of breastfeeding mothers and/or their infants is another alternative.

Before developing programmatic interventions to improve complementary feeding practices, it is essential to examine current practices in relation to the aforementioned recommendations. Although a considerable number of relevant studies have been completed in India, few are representative of the national population, and there is some indication of substantial regional variation. Space does not permit a comprehensive review of individual studies from different parts of the country, but selected findings will be highlighted to make specific points. According to several small studies, only, 37% of infants less than four months of age in slum areas of Bombay(30) and an even smaller proportion (10%) of similarly aged infants in Haryana(31) were being exclusively breastfed. A national survey of feeding practices in India in 1992-93 found that the percentage of six to nine months olds receiving solid foods in addition to breast milk varied greatly by state, ranging from only about 9% in Rajasthan to 69% in Kerala(32). Other studies(33) reported that between one-third and one-half of the children studied in Maharashtra and Gujarat did not begin eating other (non-breast milk) foods until after one year of age. Thus, it appears that in some areas of India complementary foods are introduced too early, while in other areas these foods are not started until much later than is currently recommended.

Very few quantitative studies of the composition of commonly prepared infant foods and total energy and nutrient intakes by Indian infants and children have been published, in part because of the difficulty in obtaining such information reliably, particularly from breast fed children. Moreover, in countries, such as India, where different regional food availability patterns and cultures affect dietary intake, appropriate regional sampling is necessary and the data collection instrument must be adaptable to these cultural differences(34). Whilst several methods exist to measure dietary intake, those techniques that are most accurate, such as the weighed intake method (in which all foods and beverages consumed are first weighed by an observer) and the food diary (in which the respondent records the amounts of all items consumed, usually in terms of familiar household units) may not be feasible for large-scale applications(35) because they are time consuming, costly, and possibly biased with regard to the sample of respondents who are able to comply with the demands of the research protocols(36). To overcome some of these problems, 24-hour dietary recall histories are often performed to obtain relevant data, although this method does not provide quantitative data on breast milk consumption. Moreover, the accuracy of this technique depends heavily on the skill and thoroughness with which the interview is conducted, and particular attention must be directed to assessing the portion size of items consumed. Recently, attempts have also been made to develop simplified, food frequency questionnaires that could be used by relatively untrained staff, but there is still little experience with these instruments for quantitative assessment of complementary feeding.

Once any specific inadequacies in current complementary feeding practices are identified, a number of possible programmatic approaches are available to remedy these problems(6). These interventions may include activities as diverse as dissemination of educational messages designed to encourage adoption or recommended child feeding behaviors or distribution of precooked foods specially formulated for young children. Information on appropriate child feeding may be distributed widely through mass media or through individual counselling sessions at the time of health clinic visits. Any foods that are distributed may be either provided universally to all children or targeted selectively to high risk households or to children with some identified degree of malnutrition. Ideally, complementary feeding interventions should encompass not only the food-related concerns emphasized above, but should also focus on the hygienic issues concerning food preparation and storage and on specific child feeding behaviors. A detailed discussion of the design and implementation of these programs is beyond the scope of this review, but relevant information is available in other documents(6,37).

In view of the overwhelming magnitude of the problem of undernutrition of young children and its dire consequences with regard to child mortality(38,39), serious efforts are needed to apply this newly available information on appropriate child feeding and to evaluate their outocomes in India and other similar countries.

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NOTES AND NEWS

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