2. Breast-feeding and complementary feeding: a continuum

2.1 Importance of exclusive breast-feeding in early life

The purposes of this section are to review current knowledge regarding the rationale for exclusive breast-feeding in early life, and to provide a context for the subsequent discussion of the appropriate age of introduction of complementary foods. Because the primary focus of this document is the formulation of recommendations regarding complementary feeding, this section is limited to those issues that are directly relevant to this topic, and is not intended to be an exhaustive review of all aspects of breast-feeding.

2.1.1 Successful initiation of lactation

Frequent, exclusive breast-feeding is critical for stimulating optimal milk production, especially during the first few weeks of life. Nursing frequency influences the physiological regulation of milk production in several ways, through both endocrine mechanisms (via prolactin and oxytocin) (Neville & Neifert, 1983) and autocrine mechanisms (via removal of an inhibitor of milk synthesis that builds up in the mammary gland between feedings) (Daly & Hartmann, 1995a; Daly & Hartmann, 1995b). As recently reviewed by Perez-Escamilla et al. (1994), several studies have shown that when women are randomly assigned to nurse often or "on demand" rather than according to a fixed schedule of every 3 to 4 hours, the onset of full milk production occurs sooner (Salariya, Easton & Cater, 1978), there are fewer problems of breast engorgement or sore nipples (Illingworth et al., 1952), their infants receive more breast milk and gain weight more rapidly (Illingworth et al., 1952; de Carvalho et al., 1983), and they are more likely to continue fully breast-feeding beyond the first month postpartum (Illingworth et al., 1952; Salariya, Easton & Cater, 1978).

Any practices that interfere with the infant's desire or ability to nurse effectively, such as provision of other fluids, should be avoided. Normal newborns are born with relatively high levels of tissue hydration and do not require any fluids other than breast milk (WHO, 1989), even though there may be little milk in the first 2 to 3 days. Furthermore, the use of other fluids ("prelacteal feeds") may predispose mothers to continue such practices even after milk production has been established, which can interfere with the maintenance of breast-feeding. For example, after adjusting for several potential confounders, the use of supplementary donor's milk or formula during the early neonatal period has been associated with early termination of breast-feeding (Blomquist et al., 1994). Pacifiers should also be discouraged, as there is evidence that their use is associated with more breast-feeding problems (Richard & Alade, 1992) and a shorter duration of breast-feeding (Barros et al., 1995).

Aside from any impact on nursing frequency or duration, avoidance of bottles and other artificial nipples is thought to be an effective strategy to prevent so-called "nipple
confusion" by the infant. Although this phenomenon is suspected to be common, it is not well documented and only recently has an attempt been made to define it (Neifert, Lawrence & Seacat, 1995). The physical movements of the mouth and tongue required to suckle effectively from the breast are quite different from those used to suck from a bottle or pacifier (Woolridge, 1986). Infants must learn how to breast-feed effectively when first born, and there is anecdotal evidence that some newborns have difficulty latching on to the breast and extracting milk if there is exposure to artificial nipples before breast-feeding has been successfully established (Newman, 1990; Newman, 1993; Walker, 1993). However, other investigators dispute the idea that this is due to nipple "confusion" (Fisher & Ingh, 1996). Neifert, Lawrence & Seacat (1995) distinguish early "nipple confusion" from the development of a preference for the bottle (or the breast) after breast-feeding has been established. The age at which this latter phenomenon might occur, and its impact on duration of breast-feeding, have not been described.

2.1.2 Physiological maturation

As explained in section 1.5, the immature gastrointestinal and renal function of very young infants limits their ability to handle certain constituents of non-breast-milk foods and fluids. In particular, foods with a high renal solute load may result in the need to excrete urine that is more concentrated than that which can be produced by the newborn infant's kidneys. This may be particularly critical when there are excess fluid losses for other reasons, such as diarrhoea (Wharton, 1989). The relatively high permeability of the young infant's digestive tract contributes to the risk of penetration by foreign proteins, which can cause hypersensitivity reactions (Hendricks & Badruddin, 1992). By 4 to 6 months of age, infants are developmentally mature enough to cope with foods other than breast milk.

2.1.3 Reducing morbidity and mortality

There is abundant evidence that exclusive breast-feeding in early life protects against infections and reduces mortality, particularly in developing countries where microbial contamination of foods and fluids is common (Feachem & Koblinsky, 1984; Habicht, DaVanzo & Butz, 1986; Victora et al., 1987; de Zoysa, Rea & Martines, 1991). In Peru, exclusively breast-fed infants were less likely than other infants to experience diarrhoea and respiratory illness in the first six months (Brown et al., 1989): the relative risks were particularly high for those given solid foods, but even when the only items given were non-milk fluids (waters, teas and other infusions), the prevalence of diarrhoea was doubled. This may have been attributable, at least in part, to the frequent use of feeding bottles and the frequency with which bacterial indicators of faecal contamination were recovered from the bottles (Black et al., 1989). Similarly high diarrhoeal risks due to mixed feeding were reported from the Philippines (Popkin et al., 1990).

Not only does diarrhoea occur less frequently in exclusively breast-fed infants, but when it does occur, it is less likely to have a negative impact on their nutritional status. Brown et al. (1990) found that infants did not decrease their consumption of breast milk during
diarrhoeal illness and fever, whereas their intake of energy from non-breast-milk foods and fluids decreased by 20-30%. These protective effects are the most likely explanation for the generally better growth performance during the first few months of life of infants in poor populations who receive little or nothing other than breast milk (Rowland, Rowland & Cole, 1988; Brown et al., 1991; Adair et al., 1993).

2.1.4 Avoiding displacement of breast milk by other foods and fluids

Because infant demand is the primary determinant of maternal milk production (Dewey & Lönnerdal, 1986; Dewey et al., 1991a; Daly & Hartmann, 1995a; Daly & Hartmann, 1995b), avoidance of other foods and fluids is essential to optimize breast-milk intake. Most other items offered to young infants are less nutritious than breast milk, and therefore if displacement occurs the infant may be at a nutritional disadvantage, even if the items are prepared hygienically.

The degree to which other foods or fluids displace breast milk appears to vary with the age of the infant. In rural Thailand, where early complementary feeding is very common, Drewett et al. (1993) found that for each kcal inh of non-breast-milk food given, there was a concomitant lower intake of breast milk, equivalent to -1.7 kcal inh at 15 days of age, -0.6 to -0.7 kcal inh at 45-180 days and -0.3 kcal inh at 270-360 days of age. Complementary feeding was negatively associated with the intake of breast milk even when the investigators controlled for nursing frequency, indicating that displacement is partly the result of reduced milk intake per feed and not due solely to a reduction in the number of feeds. In Peru, each kcal inh of complementary food was associated with a decrease of -0.8 kcal inh from breast milk at 1 to 2 months of age, -0.5 kcal inh at 3 to 5 months, and -0.4 kcal inh at 6 to 8 months of age, using between-child comparisons (Brown, unpublished data). When controlling for nursing frequency, these ratios were reduced by about one-third (less so at younger ages), implying that even with maintenance of the number of breast-feeds there would be some displacement. In Indonesia, van Steenberghe et al. (1991) reported that "force-feeding did not have a negative influence on breast milk intake", but their data do not seem to support that conclusion: the partially breast-fed infants consumed significantly less breast milk than those who were exclusively breast-fed during the first eight weeks, and thereafter breast-milk intake was still higher in the latter group, although the sample size was too small to make a statistical judgement.

As explained in section 2.2.3, observational studies are not ideal for drawing conclusions about displacement of breast milk by complementary foods because it may be that mothers with initially lower milk volume are more likely to begin other foods. Using within-child analyses of the data from Peru gave somewhat smaller estimates of the degree of

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1 One kcal inh is equivalent to 4.184 kJ
displacement than shown above (Brown, unpublished data). The most appropriate way to assess the impact of other foods on breast-milk intake is to use an experimental or quasi-experimental design (as described in section 2.2.4 in relation to the age period of 4 to 6 months). Nonetheless, the data summarized above indicate that while the degree of displacement may not be 100% (i.e. 1 kcal	extsubscript{a} reduction in breast milk for each kcal	extsubscript{a} of other food), there is clearly some reduction in breast-milk intake (though not necessarily in total energy intake) when other foods are introduced. If, as is usually the case, the nutritional quality of these foods is less than that of breast milk, this reduction may have a deleterious impact on the nutritional status of the infant. For example, the nutrient densities of vitamin A, riboflavin and calcium in typical cereal-based porridges are far lower than those found in human milk. Thus, even if the child's energy needs are met, the intake of several key micronutrients will be compromised if there is displacement of breast milk by such porridges.

It has been suggested that even non-caloric fluids affect breast-milk intake. Sachdev et al. (1991) reported that milk intake (and total fluid intake) was lower among breast-fed infants in India who received water supplements (n=22) compared to those assigned to an experimental group who received no additional fluids during the 8-hour daytime test period (n=23). Most of the infants had routinely received additional fluids prior to the study and were randomly assigned to the two groups. However, nine infants who had been exclusively breast-fed before recruitment were all assigned to the group that received no additional fluids. This assignment could have biased the results if the breast-milk intake of these nine infants was higher initially than that of those not previously exclusively breast-fed. Furthermore, it is possible that the differences between groups would not have been evident if test-weighing had been conducted for 24 hours rather than only 8, as water is presumably not given at night.

Numerous studies have demonstrated that the hydration status of exclusively breast-fed infants is normal even in hot climates (Armelini & Gonzalez, 1979; Goldberg & Adams, 1983; Brown et al., 1986a; Almroth & Bidinger, 1990; Sachdev et al., 1991; Ashraf et al., 1993). Thus, there is no need to provide extra fluids to breast-fed infants to satisfy their fluid requirements.

Complementary foods and fluids given prematurely may lead to an earlier cessation of breast-feeding. Martines, Ashworth & Kirkwood (1989) observed that use of such foods was associated with earlier termination of breast-feeding in southern Brazil, even when controlling for nursing frequency. Jackson et al. (1992) suggested that foods given by bottle have more of an adverse impact than foods given by other means: in rural Thailand, early use of formulas was related to earlier cessation of breast-feeding, but other foods had no impact. In affluent populations, the sustainability of mixed breast-feeding and bottle-feeding is a controversial topic. In a randomized intervention trial, Cronenwett et al. (1992) found that single daily bottle use in the first six weeks postpartum had no impact on the likelihood of continuing to breast-feed at later ages, but in about two-thirds of the cases the main fluid given by bottle was breast milk, not a substitute. If mothers express
breast milk to be fed later by bottle, the resulting stimulation to milk synthesis caused by removing milk is likely to be sufficient to avoid any decrease in milk output. By contrast, observational studies have generally shown that the regular use of breast-milk substitutes is a risk factor for early termination of breast-feeding in both developing (Popkin et al., 1983; Winikoff, Castle & Laukaran, 1989) and developed (Kurinij et al., 1984; Loughlin et al., 1985; Kurinij, Shiono & Rhoads, 1988) countries, even after controlling for planned breast-feeding duration (Perez-Escamilla et al., 1993).

Another potential consequence of the displacement of breast milk by other foods is an earlier return of maternal fertility, increasing the likelihood of a new pregnancy. The association between suckling behaviour and postpartum amenorrhea is well established (McNeilly, Glasier & Howie, 1985). When nipple stimulation is decreased because of reduced nursing frequency or total time nursing, the hormonal balance suppressing ovulation is altered. Early complementary feeding of infants has been associated with a shorter duration of postpartum infertility (Howie & McNeilly, 1982; Gray et al., 1990; Dewey et al., 1997a).

2.1.5 Bioavailability of nutrients

Use of non-breast-milk foods and fluids may interfere with the bioavailability of certain key nutrients in breast milk, such as iron and zinc. Although the concentrations of these nutrients in human milk are relatively low, when the infant is exclusively breast-fed the percentage absorbed is high (Saarinen & Siimes, 1979; Casey, Walravens & Hambidge, 1981; Sandstrom, Cederblad & Lönnerdal, 1983; Lönnerdal, 1984; Blakeborough, Gurr & Salter, 1986; Hallberg et al., 1992). Iron absorption from human milk has been shown to be substantially reduced by consumption of other foods (Saarinen & Siimes, 1979; Oski & Landaw, 1980). It is likely that foods such as cereals have the same effect on zinc absorption, particularly if the foods are consumed shortly before or after nursing. In a weaning rat pup model, zinc absorption from human milk was reduced by 25-70% when cereals were combined with milk (Bell, Keen & Lönnerdal, 1987).

2.1.6 Summary

The foregoing sections provide the rationale for recommending exclusive breast-feeding during the first several months of life, especially in developing countries where the risk of morbidity is high. As explained in the next section, the recommended duration of exclusive breast-feeding, i.e. the appropriate age of introduction of complementary foods, has been a topic of much discussion. There is general agreement that the risks of introducing other foods and fluids prior to 4 months of age outweigh any potential benefits at the population level. For this reason, the following section will focus on timing considerations after infants have reached 4 months of age.
2.2 Age of introduction of complementary feeding

This section will consider the appropriate age of introduction of complementary foods to infants who have been exclusively breast-fed during the first 4 months of life. The conclusions to be drawn are meant to apply specifically to developing countries, as they are the focus of this report. The benefit : risk ratio of complementary feeding at various ages may differ in more affluent populations.

2.2.1 Current recommendations

For several decades the World Health Organization has issued recommendations regarding the appropriate age to begin complementary feeding (e.g. Joint WHO/UNICEF Meeting on Infant and Young Child Feeding, 1979). Briefly, these recommendations since 1990 are as follows:

In 1990, the World Health Assembly (in resolution 43.3) urged Member States "to protect and promote breastfeeding as an essential component of their overall food and nutrition policies and programmes on behalf of women and children, so as to enable all infants to be exclusively breastfed during the first four to six months of life". The age range of 4 to 6 months was considered a transitional period to allow breast-fed infants to adjust to consuming solid foods (Akre, 1989).

In 1992, the 45th World Health Assembly reaffirmed (in resolution 45.34) that "during the first four to six months of life no food or liquid other than breast milk, not even water, is required to meet the normal infant's nutritional requirements, and that from the age of about six months infants should begin to receive a variety of locally available and safely prepared foods rich in energy, in addition to breast milk, to meet their changing nutritional requirements".

In 1994, the 47th World Health Assembly (resolution 47.5) urged Member States to "promote sound infant and young child nutrition in keeping with their commitment to the World Declaration and Plan of Action for Nutrition". This includes "fostering appropriate complementary feeding practices from the age of about six months, emphasizing continued breastfeeding and frequent feeding with safe and adequate amounts of local foods". UNICEF adopted the wording "about six months" in the most recent edition of its publication Facts for Life.

In 1995, the report of a WHO Expert Committee (WHO, 1995a) reaffirmed the suitability of the current recommended timing of exclusive breast-feeding and the introduction of complementary foods, i.e. 4 to 6 months of age. Thus the recommendation for exclusive breast-feeding for 4 to 6 months was reiterated, followed by the comment that "Given the worldwide variation in growth velocity, an age range is an essential element of this feeding recommendation". This has sparked debate about whether the recommendation should state an explicit age range (4 to 6 months) or if the phrase "about six months" expresses
the desired flexibility.

Two previous reviews, one sponsored by the United Nations Administrative Committee on Coordination (ACC) Sub-Committee on Nutrition (Underwood & Hofvander, 1982) and the other sponsored by WHO (Lutter, 1992), have focused on the appropriate timing of complementary feeding of breast-fed infants. In the earlier review, the conclusion of the Consultative Group on Maternal and Young Child Nutrition was that "In general, complementary foods should not be introduced to exclusively breastfed infants before four months, nor delayed beyond the age of six months. When growth falters, however, appropriate remedial steps should be taken regardless of age" (Underwood & Hofvander, 1982). The authors noted that there were many flaws in the studies available at that time, and also questioned the validity of the existing growth reference for determining when faltering occurs among breast-fed infants. The more recent review (Lutter, 1992) pointed out that "the scientific basis for the current recommendation of four to six months for the length of exclusive breastfeeding is not adequately documented" but concluded that until further research data become available, "any change in the current recommendation would be premature". The author stated that there was strong evidence of increased risk of morbidity due to complementary feeding between four and six months in developing countries, but with regard to growth there was "neither a clear advantage nor a disadvantage".

Since the above reviews were completed there have been several new studies, observational and experimental, as well as new information on energy requirements and growth patterns of breast-fed infants. Previous recommendations have been based largely on comparisons of intake and growth of breast-fed infants with existing reference data. Given the new information now available, it is worthwhile to begin by reviewing the theoretical basis underlying the timing of introduction of complementary foods.

### 2.2.2 Theoretical considerations

Ideally, the optimal age at which to introduce complementary foods should be determined by comparing the advantages and disadvantages of adding foods to the diet at various ages. The outcomes assessed should include not only infant dietary intake and growth, but also functional indicators such as infant morbidity, mortality and behavioural development as well as considerations of maternal time allocation, nutritional status, and economic costs. Although one study assessed maternal time use (and concluded that more time was required when complementary foods were added to breast-feeding; Cohen et al., 1995a), in most studies the risks and benefits measured have been limited to infant nutrition and morbidity. For example, the classic "weanling's dilemma", described by Rowland, Barrell & Whitehead (1978) with reference to developing country populations, contrasts the increased risk of disease accompanying the early introduction of solid foods against the increased risk of malnutrition from delaying the introduction of foods past the time when breast milk can no longer satisfy the nutritional needs of the infant. Whereas there has been extensive evidence of the former risk, there has been confusion over how to define
and measure the length of time that exclusive breast-feeding is nutritionally adequate. The next two sections will consider the two approaches that have been used for making this judgement, namely infant energy needs and growth patterns.

2.2.2.1 Energy needs

Much of the debate about the need for complementary foods has centred on meeting the energy requirements of infants. It is often assumed that breast milk is a complete and balanced mixture of all required nutrients for young infants, and that if the infant's energy needs are met by breast milk alone, the requirements for all other nutrients will also be met. While this may not be true for some nutrients under certain circumstances (see sections 2.2.5 and 4.3), meeting energy needs has generally been considered a key element in making infant-feeding recommendations. In this section we will argue that this approach is not particularly useful for determining the appropriate age at which to introduce complementary foods.

Until recently, it has been assumed that when the average energy intake from breast milk falls below theoretical energy requirements, additional energy sources need to be offered. However, most published estimates of energy requirements have been based on observed intakes of non-breast-fed infants fed infant formulas. We now know that energy intakes of breast-fed infants in affluent populations are significantly lower than those of formula-fed infants (Butte et al., 1984; Butte, Smith & Garza, 1990; Heinig et al., 1993a), and that the pattern of weight gain differs considerably by feeding mode after the first 2 to 3 months (WHO Working Group on Infant Growth, 1994a). In such populations, the lower energy intake of breast-fed versus formula-fed infants is not due to inadequate maternal milk production, nor to inadequate amounts of complementary foods. Rather, it appears that breast-fed infants voluntarily self-regulate their energy intake at about 80-90 kcal/kg/d (Dewey & Lönnerdal, 1986; Dewey et al., 1991a). It is common for infants to leave some "residual milk" behind in the breast after feedings (Dewey et al., 1991a; Perez-Escamilla et al., 1995). Despite the lower energy intakes and weight increments of exclusively breast-fed infants 4 to 6 months of age, they have similar motor development and reduced rates of infections compared with formula-fed infants (Dewey et al., 1991b; Dewey, Heining & Norrmen-Rivers, 1995). Thus, it seems unlikely that breast-fed infants in such environments are "underfed", and it is perhaps more plausible that formula-fed infants are "overfed".

A preferable way to determine energy needs is to measure energy expenditure and add to it the amount needed for adequate growth. Data are now available using such methodology, and have recently been tabulated by Butte (1996) (see section 3.1.2). The new estimates for breast-fed infants are very close to the observed intakes of breast-fed infants in affluent populations.

The question remains: up to what age can a breast-feeding mother provide sufficient milk to meet the energy needs of her infant? In many of the theoretical discussions of this
question, it is implicitly assumed that the milk supply of a breast-feeding woman is static - even predetermined by her "capacity" to produce milk - and that the infant's size (and thus, energy need) eventually "outstrips" the milk supply. However, this assumption is not consistent with our current understanding of the physiology of human lactation. Maternal milk production is finely tuned to the demand of the infant (Daly & Hartmann, 1995a; Daly & Hartmann, 1995b), as exemplified by the fact that mothers of twins and even triplets can successfully exclusively breast-feed for six months or more (Saint, Maggiore & Hartmann, 1986). When infant demand increases, maternal milk production can increase within days and perhaps within hours (Daly & Hartmann, 1995a; Daly & Hartmann, 1995b). Breast-milk intake by infants who are exclusively breast-fed normally increases between 3 and 6 months of age, whereas that of infants who begin receiving solids between 3 and 6 months declines (Heinig et al., 1993b). The ability of mothers to increase milk production by regularly expressing extra milk (Dewey & Lönnerdal, 1986) and to relactate after termination of breast-feeding (Phillips, 1992), and the very high milk production by mothers of twins and triplets (Saint, Maggiore & Hartmann, 1986), all suggest that human lactation is quite plastic and that in most cases milk intake by a single infant is far below potential milk production. In some species (such as rats), maternal milk supply dwindles before the offspring start to consume much other food, and the decreased availability of milk is presumably one of the triggers for eating other foods. In humans, however, it appears to be the other way around as milk "supply" declines in response to the infant's consumption of other foods. If the infant does not begin to consume other foods, there is no evidence that milk production will automatically decrease over time.

A question often raised is whether women who are malnourished can sustain adequate milk production for as long as would be desirable for the infant to be exclusively breast-fed. This, too, has been a controversial issue and has been reviewed by several authors (Prentice et al., 1986; Brown & Dewey, 1992; Lutter, 1992; Rasmussen, 1992). When adequate methodology for measuring milk volume is used, the data indicate remarkable similarity in breast-milk intake of infants in developing and developed countries (Prentice et al., 1986). For example, Brown et al. (1986b) reported that poor Bangladeshi women produced an average of 750 ml/day of breast milk when their infants were five to seven months of age, even though the women could be considered poorly nourished. Although milk fat content (and thus, energy output) may be lower in thin women, infants who are allowed to nurse on demand generally compensate for this by consuming a higher volume of milk (Perez-Escamilla et al., 1995). The evidence from supplementation studies of lactating women is conflicting; but as described in several reviews (Brown & Dewey, 1992; Rasmussen, 1992) most of the studies have had serious methodological flaws. To date, no study has met all of the necessary conditions, which include: selection of a truly malnourished population; random assignment to supplemented and control groups; measurement of both breast milk volume and energy density (by 24-hour sampling); and maintenance of exclusive breast-feeding throughout the study period. Nonetheless, the bulk of the evidence suggests that breast-milk production is relatively well buffered from maternal malnutrition, and that adverse effects are unlikely unless the mother is both thin and in negative energy balance (i.e. losing weight) (Brown & Dewey, 1992). Even in such
cases, however, the optimal solution is not to shorten the recommended period of exclusive breast-feeding, but to improve the mother's nutritional status so that lactation performance is not compromised.

To summarize, because of the plasticity of human milk production, it is difficult to judge when breast milk alone would become insufficient to meet infant energy needs. As a result, it is probably futile to use energy requirements as the basis for deciding when to introduce complementary foods at the population level.

2.2.2.2 Infant growth

Adequate growth is another criterion that has been used to determine when infants should begin to receive complementary foods. When an infant's growth deviates substantially from what is expected, growth-faltering is said to occur. This is most often judged by comparison to a reference growth curve. Using this criterion, several studies of breast-fed infants in developing countries have suggested that growth-faltering occurs as early as 2 to 3 months of age (Waterlow, Ashworth & Griffiths, 1980; Sathian, Joseph & Waterlow, 1983; Whitehead & Paul, 1984; Vis, Ruchababisha & Hennart, 1987; Zumrawi, Dimond & Waterlow, 1987). However, there are two reasons to question this conclusion. First, in most cases the infants were not truly exclusively breast-fed, and thus infections and inadequate nutrient intake due to use of non-breast-milk foods and fluids may have compromised their growth. Second, the WHO/CDC reference growth curve currently in use, which is based on predominantly formula-fed infants, does not accurately depict the expected growth pattern of breast-fed infants (WHO Working Group on Infant Growth, 1994a, Dewey et al., 1995).

In affluent populations breast-fed infants gain less weight than formula-fed infants during the first year of life. More importantly, the shape of the growth curve is different, with breast-fed infants typically showing a consistent downward trend in Z-scores relative to the current WHO/CDC reference after 2 to 3 months of age. As a result, breast-fed infants in both developed and developing countries often appear to begin faltering at the critical age of 3 to 4 months when their growth is plotted on the current growth chart. When growth of breast-fed infants in developing countries is plotted against a growth curve based on breast-fed infants in developed countries, the average age at which faltering in weight begins is later. It is 5 to 6 months for infants who are predominantly (though not truly exclusively) breast-fed in the first 4 to 6 months (WHO Working Group on Infant Growth, 1994a: data-sets from India and Peru) and 9 months for those who are exclusively breast-fed for 6 months, or exclusively breast-fed for 4 months and then given hygienically prepared complementary foods (Cohen et al., 1995b; see Figure 4 and section 2.2.4).

Several investigators have attempted to determine when growth-faltering first occurs among exclusively breast-fed infants by examining growth velocity over selected intervals (Zumrawi, Dimond & Waterlow, 1987; Hijazi, Abulaban & Waterlow 1989; Kusin et al., 1991). However, reference data for growth increments are even more problematic than
Figure 4. Weight-for-age Z-scores in Honduran and U.S. breastfed infants, by study group

Those for attained size because there is great variability in growth rate even in well-nourished populations, particularly over short (e.g. 1 month) intervals (WHO Working Group on Infant Growth, 1994a). Previous reference data for growth increments (Roche, Guo & Moore, 1989; Guo et al., 1991) underestimated this variability because they were based on predicted rather than actual growth increments (Piwoz, Peerson & Brown, 1992); thus the cut-offs derived were too high and their use would result in an overestimate of the incidence of growth-faltering.

Both weight and length are useful indices of infant growth. In most situations, weight gain is probably a more responsive indicator of the adequacy of energy intake, whereas length gain may reflect a variety of additional nutritional factors including protein and micronutrient intake as well as prenatal and genetic influences. The following paragraphs will first discuss gain in weight, and then gain in length.

Generally, monthly weight gains from 0 to 6 months are similar between breast-fed infants in developing country and affluent populations (Hijazi, Abulahan & Waterlow, 1989; Jackson et al., 1990; Dewey et al., 1992a), and in some cases weight gain in the first 2 to 4 months is significantly higher in developing country infants (presumably due to catch-up growth in response to their lower birth weight) (Jackson et al., 1990; Naing & Co, 1991; Dewey et al., 1992a; Wells, Davis & Lee, 1993; Cohen et al., 1995b). Other investigators
have reported that weight gain of breast-fed infants in developing countries is less than that of breast-fed infants in affluent populations from 4 to 6 months (Butte et al., 1992). The discrepancy in results may be related to varying degrees of exclusivity of breast-feeding across studies. As mentioned above, even calorically insignificant amounts of non-breast-milk fluids and foods can increase the risk of morbidity and thus affect growth. Unfortunately, there are very few published data on growth of infants in developing countries who were truly exclusively breast-fed for the first six months.

The above assessments are based on the pattern of weight gain over time (i.e. growth velocity), rather than on cross-sectional comparisons of attained size. Although weight gains of breast-fed infants from 0 to 6 months are generally similar in developing country and affluent populations, in many cases attained weight differs due to the lower birth weights of infants in developing countries (Whitehead & Paul, 1984). When low-birthweight infants (< 2 500 g) are excluded, attained weight of exclusively breast-fed infants in developing countries is similar to that of such infants in affluent populations during the first six months of life (Juez et al., 1983; Hijazi, Abulaban & Waterlow, 1989; Dewey et al., 1992a; Cohen et al., 1995b).

One dilemma in making such comparisons is the possibility of selection bias: breast-feeding mothers of infants who are not gaining weight adequately may begin using other foods or fluids earlier and thus no longer be categorized as exclusively breast-feeding (Martines, Ashworth & Kirkwood, 1989). Only with random assignment of mother-infant pairs to feeding groups and careful monitoring of potential attrition bias is it possible to draw firm conclusions.

With regard to length, breast-fed infants in developing countries are generally shorter relative to breast-fed infants in developed countries, even if their weights are similar in the first six months (Dewey et al., 1992a; Cohen et al., 1995b). The drop-off in length-for-age Z-scores may begin very early in infancy in some populations (WHO Working Group on Infant Growth, 1994a), in contrast to the pattern for weight-for-age. In the experimental study cited above (Cohen et al., 1994; Cohen et al., 1995b), providing hygienically safe, nutritionally adequate complementary foods beginning at 4 months had no impact on growth in length thereafter. In some settings maternal height appears to be a potent explanatory factor for the "gap" in attained length between infants in developing versus developed countries: when controlling for maternal height, the difference in length between Honduran and United States breast-fed infants disappeared (Cohen et al., 1995b). From these limited data it is difficult to determine what are the true causal factors affecting infant length, as maternal height may be a proxy for socioeconomic status or maternal nutrient intake during both pregnancy and lactation. Nutritional deficiencies during pregnancy can affect the infant's stores of certain nutrients at birth (Institute of Medicine, 1990), which could theoretically influence postnatal linear growth (Kusin et al., 1992). Likewise, inadequate maternal nutrient intake during lactation can result in low milk concentrations of some nutrients (primarily certain vitamins), though not others (protein; most minerals) (Institute of Medicine, 1991) (see section 4.3.3). However, if inadequate
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Infant nutrient intake were the primary determinant, one would expect that the addition of the nutrient-rich complementary foods in the Honduras intervention study (Cohen et al., 1994) would have resulted in an acceleration in length velocity, which did not occur. It thus seems more likely that the difference in attained length between the Honduran and United States infants is a direct effect of maternal size, though it is unclear whether this operates through genetic or gestational mechanisms, or both. Further research is needed to disentangle the causal factors.

The above discussion illustrates the difficulty in using infant growth patterns to make judgements about the need for complementary foods. Growth rates of fully breast-fed infants in developing countries are generally similar to those of their counterparts in more affluent populations during the first six months of life. As pointed out by Lutter (1992), even if growth-faltering occurs during this period, "it does not support the hypothesis that the growth of these infants would improve with complementary feeding. In fact, the opposite might be true." This hypothesis can only be tested by comparing infants who are exclusively breast-fed with those given complementary foods within a given population. The next two sections present data from observational and experimental studies that have used this approach.

2.2.3 Results of observational studies

Two previous reviews of this topic provided extensive documentation of relevant studies prior to 1990 (Underwood & Hofvander, 1982; Lutter, 1992). It was concluded that there were serious limitations to nearly all of these studies, which precluded making a definitive statement about the impact of complementary foods on infant intake and growth. For this reason, the following two sections will focus on recent data not included in the previous reviews, with earlier studies cited when appropriate.

2.2.3.1 Developed countries

Two studies in the United States of America have specifically compared the intake and growth of breast-fed infants before and after the introduction of solid foods (Stuff & Nichols, 1989; Heinig et al., 1993b). In the first (Stuff & Nichols, 1989), mother-infant pairs were divided into three self-selected groups based on the age at which solid foods were introduced: between 16 and 20 weeks (n=19); between 20 and 24 weeks (n=18); and after 24 weeks (n=8). Breast-milk intake did not differ among groups at baseline (when still exclusively breast-fed), but declined significantly in each group shortly after solid foods were introduced. Total energy intake (including energy from foods) did not differ significantly among groups at any time point. Inspection of the data indicates that for each kcal of solid food added, there was an average decrease of 0.7 kcal from breast milk. In the second study (Heinig et al., 1993b), breast-fed infants who were given solid foods before 6 months of age (n=41) were compared with those given solids at 6 months or later (n=19). Breast-milk intake was similar between groups at 3 months, when both groups were still exclusively breast-fed, but was 141 g/d lower at 6 months in the "early solids"
group. There were no significant differences in total energy intake between groups at 3 or 6 months. Average Z-scores for weight-for-age, length-for-age and weight-for-length did not differ between groups at any time point. Weight gain was similar between groups at 4 to 6 and 9 to 12 months but was lower in the "late solids" group at 6 to 9 months; there were no significant differences in length gain.

The results of these two studies suggest that introducing solid foods before 6 months had little impact on total energy intake or growth of breast-fed infants in affluent populations, although the statistical power to detect such differences may have been too low due to the relatively small sample sizes. This conclusion was borne out by growth analyses of a pooled sample of 453 breast-fed infants from six industrialized countries, in which two different cut-offs for the age of introduction of solid foods were utilized: before or after 6 months, and before or after 8 months (Dewey et al., 1995). In neither case was average gain in weight or length lower (at any time during the first 12 months) in those still predominantly breast-fed (defined as receiving no foods other than breast milk, except for water-based drinks), compared to those receiving other foods. However, in all of these studies self-selection bias is a serious limitation, because parental decision to begin feeding solid foods is based in part on factors that may independently affect the outcome measures. For example, infants who were heavier to begin with were more likely to be given solid foods at a later age (Dewey et al., 1995).

In an attempt to overcome this limitation, data from the above pooled sample were further analysed to examine specifically the period from 4 to 6 months, with and without controlling for initial size at 4 months. Infants who had been predominantly breast-fed during the first 4 months and not weaned before 6 months were subdivided into four groups based on feeding mode from 4 to 6 months: only breast milk (n=200); breast milk plus solid foods (n=122); breast milk plus other milk (generally infant formula) (n=6); and breast milk plus solid foods and other milk (n=30). Table 4 shows weight and length gain from 4 to 6 months in these four groups. There were no significant differences in weight or length gain among groups, with or without controlling for initial weight or length (although the small sample size of the third group limits the statistical power for comparisons involving that group). These results support the hypothesis that in affluent populations, introduction of solid foods between 4 and 6 months does not influence infant growth.

2.2.3.2 Developing countries

Numerous attempts have been made to examine the potential growth impact of non-breast-milk foods during the first six months in developing countries. The discussion below will focus on those studies with data relevant to the interval from 4 to 6 months, as this is the period of greatest uncertainty with regard to formulating recommendations. In most such studies, a self-selected group of "exclusively" breast-fed infants has been compared with a group of breast-fed infants given other foods. The lack of random assignment to groups or statistical control for confounding variables, the possibility of attrition bias, and the
Complementary feeding of young children in developing countries

Table 4. Weight and length gain from 4-6 months by feeding mode; pooled data set of North American and Northern European infants who were predominantly breast-fed during the first four months of life (Dewey et al., 1995)

<table>
<thead>
<tr>
<th>Feeding mode 4-6 months</th>
<th>Exclusively breast fed</th>
<th>Breast-fed + solids</th>
<th>Breast-fed + other milk</th>
<th>Breast-fed + other milk &amp; solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>200</td>
<td>122</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Weight gain (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>925</td>
<td>936</td>
<td>1181</td>
<td>911</td>
</tr>
<tr>
<td>(SD)</td>
<td>(283)</td>
<td>(330)</td>
<td>(248)</td>
<td>(288)</td>
</tr>
<tr>
<td>Length gain (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>3.44</td>
<td>3.48</td>
<td>3.71</td>
<td>3.68</td>
</tr>
<tr>
<td>(SD)</td>
<td>(0.86)</td>
<td>(0.96)</td>
<td>(0.95)</td>
<td>(0.98)</td>
</tr>
</tbody>
</table>

variable definitions of "exclusive breast-feeding" make interpretation of such studies difficult. Reverse causation is also a possibility in cross-sectional studies. For example, Launer, Habicht & Kardjati (1990) found that infants in Indonesia who were larger and healthier were more likely to be left in the care of others and, as a result, less likely to be fully breast-fed. By contrast, Simondon & Simondon (1995) reported that in Senegal, breast-fed infants fed millet gruel were thinner than those who were predominantly breast-fed at 4-7 months, and concluded that this association may have resulted from mothers preferentially feeding the gruel to thinner infants. In subsequent analyses (excluding infants fed complementary foods by 2 to 3 months), they found no significant differences in weight gain from 4-5 to 6-7 months between infants still predominantly breast-fed and those already being given complementary foods at the beginning of the interval. However, growth in length during this interval was significantly higher (p<0.05) in those predominantly breast-fed at 4-5 months (Simondon & Simondon, 1997).

The latter approach - comparing growth rates over selected intervals rather than attained size - is preferable, as it eliminates some (though not all) of the difficulties in interpretation (such as the effects of birth weight and early growth rate on attained size at six months). Ideally, feeding mode should be carefully categorized throughout the interval of comparison, and regression analysis should be used to control for weight or length at the beginning of the interval and for other potentially confounding variables. Recent studies in five countries have included data on growth velocity and feeding mode during the relevant period (Zumrawi, Dimond & Waterlow, 1987; Brown et al., 1991; Kusin et al., 1991; Harrison, Brush & Zumrawi, 1992; Adair et al., 1993; Brush, Harrison & Zumrawi, 1993; Martines et al., 1994). The results of each of these studies are described briefly below (see Table 5).

In the Sudan, Zumrawi, Dimond & Waterlow (1987) found no significant differences in weight gains from 16 to 20, 20 to 24 and 24 to 28 weeks between infants who were
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Country</th>
<th>Method of Analysis</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adair et al.</td>
<td>1993</td>
<td>Philippines</td>
<td>Wt. &amp; ln. gain 4-6 mo compared between FBF (N=370) and PBF (N=834)</td>
<td>No difference</td>
</tr>
<tr>
<td>Brown et al.</td>
<td>1991</td>
<td>Peru</td>
<td>Regression analysis of wt &amp; ln. gain 4-6 mo with proportion of energy intake from comp. foods (N=118) Wt. &amp; ln. gain 4-6 mo compared between FBF (N=15) and PBF (N=21)</td>
<td>No association No difference</td>
</tr>
<tr>
<td>Harrison, Brush &amp; Zumrawi</td>
<td>1992</td>
<td>Sudan</td>
<td>Regression analysis of wt. gain 0-12 mo with age of intro. of comp. foods (N=203)</td>
<td>Later intro. of comp. foods associated with greater wt gain</td>
</tr>
<tr>
<td>Zumrawi, Dimond &amp; Waterlow</td>
<td>1987</td>
<td>Sudan</td>
<td>Wt. &amp; ln. gain at 16-20, 20-24 &amp; 24-28 wk compared between EBF (N=115, 58 &amp; 25) and PBF (N=228, 291, 324)</td>
<td>No difference in wt. gain; ln. gain higher in EBF at 20-24 wk</td>
</tr>
<tr>
<td>Kusin et al.</td>
<td>1991</td>
<td>Indonesia</td>
<td>Correlation analysis of wt. gain with energy intake from comp. foods (N=76) at 14-22, 18-26 &amp; 22-30 wk</td>
<td>No association 14-22 &amp; 18-26 wk; greater wt gain in those with less comp. foods at 22-30 wk</td>
</tr>
<tr>
<td>Martines et al.</td>
<td>1994</td>
<td>Brazil</td>
<td>Wt. gain at 4-5 &amp; 5-6 mo compared among predominantly BF (N=57, 33), PBF (N=145, 145) and Non-BF (N=183, 212)</td>
<td>No difference between predominantly BF and PBF</td>
</tr>
</tbody>
</table>

EBF = exclusively breast-fed  
FBF = fully breast-fed (little or no nutritive foods or fluids other than breast milk)  
PBF = partially breast-fed (complementary foods and/or other milks and drinks in addition to breast milk)
exclusively breast-fed (n=115, 58 and 25 in each interval, respectively) and those who were given complementary foods (n=228, 291 and 324, respectively); length gain was significantly higher in the exclusively breast-fed group only during the interval from 20 to 24 weeks. The authors also examined whether mothers began feeding complementary foods because of infant growth-faltering: there was no evidence of any difference in prior growth between infants who were subsequently given foods and those who continued to breast-feed exclusively. In a later analysis of a subset of 203 infants (Harrison, Brush & Zumrawi, 1992), weight gain from birth to 12 months was positively associated with a later age of introduction of complementary foods, even when controlling for birth weight, socioeconomic status and morbidity. The typical age of introduction of foods was 3 to 5 months. In a subsequent path analysis involving 439 infants (Brush, Harrison & Zumrawi 1993), the authors concluded that age of introduction of complementary foods and illness were the most important determinants of gain in both weight and length during the first year of life; infants given complementary foods later gained more than those to whom foods were introduced at an earlier age.

In Indonesia, Kusin et al. (1991) used correlation analysis to examine the relationship between weight gain and the amount of energy from complementary foods consumed by 76 breast-fed infants. This correlation was not significant during the eight-week intervals beginning at 14 or 18 weeks (r=0.11 and 0.10, respectively), but was significantly negative from 22 to 30 weeks (r=-0.46, p<0.01). In other words, infants who consumed more energy from complementary foods during this age interval gained less weight. Length gain in relation to complementary feeding was not examined.

In Peru, Brown et al. (1991) demonstrated that infant growth during the first six months was positively related to the proportion of energy provided by breast milk. These data were subsequently re-analysed to examine determinants of growth from 4 to 6 months among 118 breast-fed infants (Brown, personal communication). There was no significant correlation between the amount of energy from complementary foods and either weight gain (r=-0.04) or length gain (r=0.02) during this interval. The results were not altered when multiple regression analyses were performed controlling for infant sex, initial weight or length at 4 months, morbidity and maternal height. When comparing infants who were fully or exclusively breast-fed for 6 months (n=15) with those who were fully or exclusively breast-fed for 4 months and then partially breast-fed (n=21), there were no significant differences in weight gain (804±395 vs. 717±336 g, respectively) or length gain (3.26±0.54 vs. 3.14±0.88 cm, respectively) from 4 to 6 months, with or without controlling for initial size at 4 months. However, the small sample sizes limit the statistical power for this comparison.

In the Philippines, Adair et al. (1993) studied determinants of growth of approximately 3000 infants from birth to 24 months. Full breast-feeding (defined as no other nutritive foods or liquids) and mixed breast-feeding (breast-feeding plus nutritive foods or liquids) were strongly associated with greater weight gain during the first six months of life, compared with mixed breast-feeding or no breast-feeding, respectively. To evaluate
growth from 4 to 6 months, a new analysis was performed to compare two subgroups: those who were fully breast-fed throughout the first 6 months (FBF; n=370) and those who were fully breast-fed for the first 4 months and then partially breast-fed (PBF; n=834). Neither weight gain nor length gain from 4 to 6 months differed significantly between groups (weight gain: 671±313 in FBF vs. 699±334g in PBF; length gain 3.2±1.6 in FBF vs. 3.2±1.5cm in PBF). Multiple regression analysis controlling for infant sex, maternal height, education, urban/rural residence and season did not change these results (Adair, personal communication).

In Brazil, Martines et al. (1994) compared monthly weight gains of infants categorized into three groups: predominantly breast-fed, partially breast-fed, and non-breast-fed. Groups were further subdivided on the basis of whether the family did or did not have an indoor water tap. There were no significant differences in weight gain from 4 to 5 months (n=57, 145 and 183 in the three feeding groups, respectively); from 5 to 6 months weight gain was higher in the non-breast-fed group (n=212) (interpreted by the authors to reflect catch-up growth after growth-faltering in the first 3 months) but there was no significant difference between the two breast-fed groups (n=33 and 145, respectively), regardless of the source of water. Length gain was not examined.

These results suggest that in some environments (e.g. the Sudan, Indonesia) there may be a growth advantage with exclusive/full breast-feeding beyond 4 months compared with partial breast-feeding, but in others (e.g. Peru, the Philippines, Brazil) there is no significant difference in growth velocity from 4 to 6 months between feeding groups. None of these studies showed a growth advantage in the complementary feeding of breast-fed infants prior to 6 months, although small sample size may limit the power to detect such differences in some cases.

The evidence with regard to diarrhoeal morbidity is relatively clear, although only two studies were found in which the data were shown by subgroups of age and relative to exclusively breast-fed infants (Brown et al., 1989; Popkin et al., 1990). Table 6 shows that the relative risk of diarrhoea among breast-fed infants given complementary foods at 3 to 5 months in the Peruvian study (Brown et al., 1989), compared to exclusively breast-fed infants, was 3.35 (p<0.001) using prevalence data and 1.79 (not significant) using incidence data. In the Philippines (Popkin et al., 1990), the relative risk of diarrhoea incidence for those given complementary foods at 4 or 6 months, compared to exclusively breast-fed infants, ranged from 4.73 to 6.30 in the rural sample and from 10.61 to 12.93 in the urban sample (all highly significant).

Given these large differences in morbidity by feeding mode, one might ask why some of the studies described above did not show a significant growth difference in favour of exclusive breast-feeding. One possible explanation is that breast-feeding, even if it is not exclusive, mitigates the detrimental effects of illness on growth (Launer, Habicht & Kardjati, 1990; Adair et al., 1993; Martines et al., 1994). Another possibility is that complementary foods may increase total energy intake to some extent, despite partial
Table 6. Relative risk of diarrhoea by feeding mode

*Brown et al., (Peru) (N=153)*

<table>
<thead>
<tr>
<th>Relative risks of diarrhoea prevalence and incidence at 3-5 months:</th>
<th>Prevalence</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusive BF</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>BF + other liquids</td>
<td>2.04*</td>
<td>1.44</td>
</tr>
<tr>
<td>BF + artificial milks</td>
<td>2.35*</td>
<td>1.77</td>
</tr>
<tr>
<td>BF + solids</td>
<td>3.35*</td>
<td>1.79</td>
</tr>
</tbody>
</table>

*Popkin et al., 1990 (Philippines) (N=3080)*

<table>
<thead>
<tr>
<th>Relative risk of diarrhoea incidence by age and urban-rural site:</th>
<th>Urban 4 months</th>
<th>Urban 6 months</th>
<th>Rural 4 months</th>
<th>Rural 6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusive BF</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>BF + non-nutritive liquids</td>
<td>2.12*</td>
<td>3.18*</td>
<td>1.97*</td>
<td>2.21*</td>
</tr>
<tr>
<td>BF + nutritive foods</td>
<td>12.93*</td>
<td>10.61*</td>
<td>6.30*</td>
<td>4.73*</td>
</tr>
</tbody>
</table>

* Significantly different from exclusively breast-fed group

displacement of breast milk, which could offset the negative effects of increased morbidity. Regardless of whether there is or is not a growth impact of diarrhoeal morbidity during the period of 4-6 months, the likely increased risk of dehydration and death imposed by the elevated incidence rates is of obvious concern.

2.2.4 Results of experimental studies

The strongest study design for evaluating the optimal age of introduction of complementary foods is to randomly assign exclusively breast-fed infants to receive additional food at different ages. If the complementary foods add significantly to the infants’ total energy intake and increase the rate of growth, it might be assumed that breast milk alone was not meeting the children’s physiological needs. If, on the other hand, these additional foods simply replace breast milk and there is no increase in total energy intake or growth, it might be assumed that the infants’ energy needs were being satisfied with breast milk alone. In the latter case, the net impact of complementary foods under optimal environmental conditions might be neutral at this age (i.e. 4 to 6 months). However, under "real-world" conditions in developing countries, in which there is a high frequency of microbial contamination of complementary foods, it could be concluded in the latter case that delayed introduction of these foods would be preferable.
The above experimental design was used in a study recently completed in Honduras (Cohen et al., 1994; Cohen et al., 1995a; Cohen et al., 1995b; Cohen et al., 1995c; Perez-Escamilla et al., 1995; Dewey et al., 1996a). Low-income primiparous mothers who had exclusively breast-fed during the first 4 months postpartum were randomly assigned (by week of birth) to one of three groups: continued exclusive breast-feeding to 6 months (EBF; n=63); introduction of complementary foods at 4 months, with ad libitum nursing from 4 to 6 months (SF; n=51); and introduction of complementary foods at 4 months, with maintenance of baseline nursing frequency from 4 to 6 months (SF-M; n=50). The foods offered to the SF and SF-M groups were designed to satisfy the requirements for all essential nutrients and were commercially prepared, precooked and sealed in jars to assure that they were free of microbial contamination. This approach was taken to avoid the potentially confounding effects of increased morbidity and inadequate nutrient density in the SF and SF-M groups if home-prepared foods had been utilized. Mothers were provided with lactation guidance throughout the study. At 4, 5 and 6 months, measurements were made of infant intake (via 2 days of test-weighing) and breast milk composition (based on samples collected by alternate breast expression over a 24-hour period) by having the mother-infant pairs stay at a central facility for 3 days each time. After 6 months, all mothers continued to breast-feed and also fed their infants home-prepared complementary foods after receiving instruction in appropriate feeding practices.

Of the 164 infants who began the intervention, 141 completed all measurements to 6 months (n=50, 47 and 44 in the EBF, SF and SF-M groups, respectively). There were no significant differences between drop-outs and those who completed the study in maternal age; education; body mass index; marital status; prenatal care; income; infant birth weight; sex; weight gain from birth to 4 months; weight at 4 months; or breast-milk intake at 4 months. This was also true when comparing drop-outs and participants separately within each intervention group. Only two of the drop-outs from the EBF group left the study because of perceived "insufficient milk" or the desire to introduce other foods (aside from those who had to use breast-milk substitutes because they went back to work); in neither case was there evidence of low breast milk volume or poor infant weight gain before dropping out.

When complementary foods were introduced, nursing frequency declined spontaneously. In the SF-M group, mothers reported that infants demanded less frequent feedings, but they continued to offer the breast even if the infants did not signal any interest. Between 4 and 6 months, breast-milk intake (g/d) was unchanged in EBF infants (+6) but decreased significantly in the SF (-103) and SF-M (-62) groups. Change in total energy intake (including solid foods) was similar across groups: there was a non-significant difference of about +35 kcal/d (about 6% of total energy intake) in the groups given solid foods compared to the EBF group. Displacement of breast milk was somewhat less in the group asked to maintain nursing frequency: for each kcal of solid foods consumed, there was a decrease in breast-milk energy intake of 0.6 kcal in the SF group and 0.3 kcal in the SF-M group. The former ratio (0.6 : 1.0) is similar to the values seen in both Thailand (Drewett et al., 1993, see section 2.1.4) and the United States of America (Stuff & Nichols,
1989, see section 2.2.3.1) among mother-infant pairs breast-feeding *ad libitum*.

In all three intervention groups, infants did not consume all of the breast milk that was potentially available to them at 4, 5 and 6 months (Perez-Escamilla et al., 1995), implying that their energy needs were being satisfied both before and after the intervention. This was determined by calculating "residual milk volume", which is the difference between the mother's total milk production on the day of milk sampling (when approximately half of total milk output was expressed using an electric breast pump) and the infant's average intake on the 2 days of test-weighing. Residual milk volume averaged about 95 g/d at 6 months, and was significantly lower in the SF group than in the EBF and SF-M groups.

There were no differences in weight or length gain among groups, either during the intervention period (4 to 6 months) or thereafter (6 to 12 months) (Figure 4). Rates of infectious morbidity were similar across groups, presumably because of the hygienic conditions under which the complementary foods were provided.

The data on food intake at five and six months are useful for evaluating whether there is a need for a "transition period" before infants can consume the desired quantity of complementary foods. Energy intake from solid foods averaged about 94 kcal/kg/d at five months and 107 kcal/kg/d at six months in the two solid foods groups, a difference of only 13 kcal/kg/d between five and six months. Thus, it appeared that the infants stabilized their daily intake within the first month after the introduction of solid foods.

Food intake measurements were continued during the follow-up period (from 6 to 12 months) to determine whether there were any longer-term effects of the intervention on infant food acceptance. At 9 and 12 months, there were no significant differences among groups in breast-feeding frequency; amount or number of foods consumed at the midday meal; percentage of food offered that was consumed; usual daily number of meals and snacks; number of food groups consumed; or overall food acceptance score (Cohen et al., 1995c).

Blood samples were collected at six months of age to evaluate the risk of iron deficiency. These results are discussed in section 2.2.5.

Low-birth-weight infants (< 2 500 g) are particularly vulnerable to nutritional deficits because they are more likely to be born to malnourished mothers and to have lower stores of several key nutrients at birth. The Honduras study had too few low-birth-weight infants to draw definite conclusions regarding the impact of the intervention, but the data suggested that there were no differences in growth or intake among groups. For example, among the 28 low-birth-weight infants, mean weight gain from 4 to 6 months in the EBF, SF and SF-M groups was 1008±326, 994±273 and 1038±34 g, respectively. The data indicate that the growth rate of the low-birth-weight infants (all full-term) was similar to that of the normal-birth-weight infants. However, because they started out much smaller, their average Z-score at 6 months was -0.70 for weight-for-age (compared to 0.17 for the
normal-birth-weight Honduran infants) and -1.42 for length-for-age (compared to -0.36 for normal-birth-weight infants) (Cohen et al., 1995b). Although growth rates of the low-birth-weight infants appeared to be normal, the risk of iron-deficiency anaemia was high, as discussed in section 2.2.5.

Data from the Honduras study were also analysed according to the mother's body mass index (BMI: wt/ht²) (Cohen et al., 1994). Of the 47 infants whose mothers had a BMI < 21 kg/m², weight and length gain from 4 to 6 months were similar across the three intervention groups. While this suggests that the provision of complementary foods did not alter growth performance of this higher-risk subgroup, the statistical power for this comparison was limited by sample size, and further data are needed from populations with more severe maternal malnutrition.

In summary, the results of the study indicate that in regard to the growth of breast-fed infants in this population there was no advantage in complementary feeding before 6 months of age. The lack of any negative effect of the intervention may be attributable to the high nutritional and hygienic quality of the foods provided.

2.2.5 Risk of nutritional deficiencies during exclusive breast-feeding

It is well recognized that human milk is the ideal food for young infants because of its unique nutritional characteristics (Institute of Medicine, 1991). Nonetheless, for some nutrients it is likely that the amount provided through breast milk alone will be insufficient after a certain age. This has been discussed extensively with respect to iron, but there are other nutrients that deserve attention as well, such as zinc. In addition, some nutrients may be in low concentration in human milk if the mother is malnourished, particularly certain vitamins, such as Vitamin A and many B vitamins (see section 4.3.3). In this section the existing data on the risk of nutritional deficiencies among infants who are exclusively breast-fed will be briefly reviewed.

It has been argued that the growth rate of exclusively breast-fed infants may be limited by their protein intake (Fomon, 1993). Data from the intervention study in Honduras described above were used to examine this issue (Dewey et al., 1996a). Because the solid foods groups were given foods that included egg yolk, which is high in protein, their protein intake was 20% higher than that of the exclusively breast-fed group. The lack of any impact on growth, even when the extremes of the protein intake distribution were compared, was taken as evidence that protein was not a limiting nutrient. These results were consistent with those from a study of breast-fed infants in the United States of America, in which protein density of the diet was unrelated to growth throughout the first year of life (Heinig et al., 1993a).

Iron status of breast-fed infants has been a topic of various studies because the concentration of iron in human milk is relatively low (although it is highly bioavailable). In addition to the iron provided by breast milk, infants use the iron reserves present at birth.
to supply their needs for red blood cell synthesis and growth. As a result, there is normally a reduction in liver iron stores during the first six months of life (Saarinen & Siimes, 1979; Dallman, 1986). Data from affluent populations indicate that in normal-birth-weight infants who are exclusively breast-fed, there is little risk of iron-deficiency anaemia prior to nine months of age, although biochemical indices of low iron status (not severe enough to cause anaemia) may occur in some between six and nine months (Siimes, Salmenpera & Perheentupa, 1984; Duncan et al., 1985; Lönnrdal & Hernell, 1994). However, the risk of iron deficiency is greater in low-birth-weight infants because their iron stores at birth are much smaller. Therefore, in developing countries in which there are relatively high percentages of low-birth-weight infants, the likelihood of iron deficiency during the first six months of life is increased. Other factors may also contribute to iron deficiency among young infants in developing countries, such as maternal iron deficiency during pregnancy (Colomer et al., 1990; Bhargava et al., 1991) and premature clamping of the umbilical cord at the time of delivery (Wilson, Windle & Alt, 1941; DeMarsh, Windle & Alt, 1942; Fairweather-Tait, 1992; Grajeda, Pérez-Escamilla & Dewey, 1997).

In the Honduran intervention study described above, there was a relatively high rate of anaemia at six months (27% with haemoglobin < 10.3 g/dL); the prevalence was similar between exclusively breast-fed infants (32%) and those given solid foods (25%), even though the foods provided were fortified with iron. However, only 10% of the infants had a low serum ferritin concentration (< 12 µg/L) indicative of iron deficiency. Similar results were reported in Argentina (Calvo, Galindo & Aspnes, 1992). Data from Sweden (Lönnrdal & Hernell, 1994) indicate that haemoglobin concentrations are normally at a low point at around six months, despite no evidence of abnormalities in any indices of iron status. Therefore, it appears that revised cut-offs for diagnosing anaemia at that age are needed. It is clear, however, that the infants at highest risk for iron deficiency are those born with low birth weight. Of the low-birth-weight infants in the Honduran study, 46% were anaemic and 22% had low ferritin concentrations at six months, compared to 12% and 0% respectively, among those with birth weight > 3 000 g (Dewey et al., 1998). Because the provision of iron-fortified complementary foods did not appreciably reduce the risk of anaemia at 6 months, it may be preferable to focus on other strategies to reduce iron deficiency among exclusively breast-fed infants, such as enhancing maternal health and nutritional status to reduce rates of low birth weight, and promoting later clamping of the umbilical cord to assure adequate transfer of blood and associated nutrients to the newborn. It is generally advised that low-birth-weight infants receive supplemental iron from about 3 months of age onward (UNICEF/WHO, 1995). In situations in which additional iron is warranted prior to six months in normal-birth-weight infants, this might also be best accomplished by providing iron supplements in the form of medicinal drops rather than potentially contaminated food.

Zinc is another nutrient which is relatively low in human milk, even though its bioavailability is high. Plasma zinc data from affluent populations do not suggest that exclusively breast-fed infants are at higher risk of zinc deficiency during the first six months of life than those who are fed zinc-fortified formulas (Hambidge et al., 1979). In
the Honduran intervention, infants given solid foods received twice as much zinc as those who were exclusively breast-fed (and zinc bioavailability from the foods should have been satisfactory based on their low phytate to zinc molar ratio), yet there was no difference in weight or length gain (Dewey et al., 1996a). Although zinc intake from 6 to 12 months may be deficient in some populations, relative to recommended levels (see section 4.5.3), there is no evidence to date that zinc deficiency is a problem among exclusively breast-fed infants prior to 6 months (Dewey et al., 1992b; Krebs et al., 1994; Michaelsen et al., 1994; Salmenpera et al., 1994). Walravens et al. (1992) reported an increase in growth rate in response to 3 months of zinc supplementation of breast-fed infants whose mean age at the beginning of the intervention was 5.7 months, but these infants were no longer exclusively breast-fed, and several concerns were raised about the study’s conclusions (Dewey et al., 1992b).

In some circumstances, exclusively breast-fed infants may not receive enough of certain vitamins and trace elements such as iodine and selenium (Institute of Medicine, 1991). In particular, there is a possibility of vitamin D deficiency among infants who do not receive much exposure to sunlight, such as those in northern latitudes or those who are kept completely covered when outside (Institute of Medicine, 1991). Breast-fed infants of mothers who are complete vegetarians may exhibit signs of vitamin B₁₂ deficiency (Institute of Medicine, 1991). Biochemical indices of riboflavin deficiency have been detected in infants of mothers with very low riboflavin intakes (Bates et al., 1982a). Aside from these examples, there are very few situations in which nutritional deficiencies are observed in exclusively breast-fed infants during the first six months. Even in populations with a high prevalence of vitamin A deficiency, the risk of xerophthalmia while exclusively breast-fed is very low (West et al., 1986; Mahalanabis, 1991). In all of the above situations, improving the mother’s diet or giving her supplements (in the case of vitamin B₁₂, riboflavin, vitamin A) or giving vitamin drops directly to the infant (in the case of vitamin D) is the recommended strategy to prevent deficiencies, as it cannot be guaranteed that complementary foods will have sufficient nutrient density and they may increase the risk of morbidity.

2.2.6 Summary

The evidence described above indicates the following:

1. Because of the plasticity of human milk production, it is probably futile to use energy requirements as the basis for deciding when to introduce complementary foods at the population level.

2. Growth rates of fully breast-fed infants in developing countries are generally similar to those of their counterparts in more affluent populations during the first six months of life. However, the possibility of attrition bias in observational studies makes it difficult to draw definitive conclusions.
3. In affluent populations, growth rates of infants who are exclusively breast-fed during the first six months or more are similar to those of infants given solid foods between four and six months, probably because of displacement of breast milk by complementary foods.

4. In disadvantaged populations, data from observational studies in five countries show that in some environments there may be a growth advantage with exclusive breast-feeding beyond four months, but in others there is no significant difference in growth velocity from four to six months between feeding groups. None of these studies showed a growth advantage of complementary feeding of breast-fed infants prior to six months.

5. Based on two observational studies, the risk of diarrhoeal morbidity in poor populations is 2-fold to 13-fold higher when breast-fed infants are given complementary foods between four and six months than when they are exclusively breast-fed.

6. There has been only one experimental study to evaluate the impact of complementary foods on intake and growth of breast-fed infants from four to six months. That study indicated that there was no difference in growth between exclusively breast-fed infants and those given hygienically prepared nutritionally adequate foods during this period. There was significant displacement of breast-milk intake by complementary foods, even when nursing frequency was maintained. The results were similar for vulnerable subgroups such as low-birth-weight infants and infants born to mothers with relatively low BMIs, although sample sizes were too small to draw firm conclusions for such cases.

7. Micronutrient deficiencies can occur among infants who are exclusively breast-fed during the first six months, although clinical signs of such deficiencies are rare. The nutrients of greatest concern include iron, vitamins A, D, B₁₂, riboflavin and possibly zinc. Low-birth-weight infants are at greatest risk of iron deficiency. Complementary foods may or may not reduce the risk of such deficiencies. In the case of vitamin deficiencies, maternal dietary improvement or supplementation is likely to be effective, and this will benefit both the mother and the infant. In the case of iron, supplemental iron drops are recommended for low-birth-weight infants, and may also be more effective than the introduction of foods for normal-birth-weight infants who are iron deficient.

There are two viewpoints with regard to the conclusions that should be drawn from the above in terms of infant-feeding policies for developing countries. Some would argue that there is insufficient evidence to support a recommendation for exclusive breast-feeding for about six months (rather than stating "four to six months"). The data from observational studies can be criticized because of the many limitations described in the above sections. Experimental studies are preferable, but there has been only one so far, and there is a need to replicate the findings of that study in other settings and for certain vulnerable subgroups. The statistical power of the Honduras study, though adequate for the growth outcomes, was relatively low for detecting differences in energy intake. In general, there is a lack of information on outcomes other than infant growth and morbidity, such as maternal nutritional status. Adherents to this school of thought would thus conclude that it is safer
to recommend introduction of complementary foods at four to six months until further data are available.

The other viewpoint is that the evidence as a whole is sufficient to support a recommendation that full-term infants with appropriate weight-for-gestational-age should be exclusively breast-fed until about six months of age. However, more information may be needed before authoritative programmatic recommendations can be formulated for low-birth-weight infants. Although there is always a need for further research, adherents to this school of thought would argue that there is already strong evidence of increased risk of morbidity due to complementary feeding before six months in disadvantaged populations, and considerable evidence that there is no benefit with regard to infant growth from four to six months. Even if energy intake increases slightly with complementary feeding (e.g. by about 35 kcal/d), the energy costs of the increased morbidity that is likely to occur in unhygienic environments will generally be similar (Lutter, 1992), resulting in no net gain in terms of long-term energy balance. For other nutrients, the potential gain from complementary foods would likely be offset by the losses from both increased morbidity and the reduced bioavailability of some nutrients from breast milk when other foods are given. When there is risk of maternal malnutrition, proponents of this viewpoint would point out that these are the same conditions under which complementary foods are most likely to be contaminated and of poor nutritional quality. In such cases, maternal dietary or micronutrient supplementation is likely to be a more effective and less risky strategy to prevent deficiencies in both the mother and infant (at least for vitamins) than use of complementary foods. Thus, their conclusion would be that it is safer to recommend exclusive breast-feeding until about six months.

The primary authors of this report take the second viewpoint. There are several advantages to a recommendation stating "about six months" rather than an age range of four to six months. An age range is vulnerable to misinterpretation by health care workers, parents, (Koniz-Booher et al., 1991) and food companies with a vested interest in earlier introduction of transitional foods. Health care workers have been known to encourage the introduction of complementary foods by four months just "to be safe", and parents often provide "tastes" of foods long before four months in the belief that the infant should be eating complementary foods well by four months. Although the prevalence of exclusive breast-feeding for even four months is low in most regions (see section 7.1), and reaching the desired duration of about six months is an ambitious goal, this is not an adequate argument for adopting a recommendation that is a compromise between what is optimal for infant health and what is currently achievable. Some policy-makers would argue that mothers in areas where early complementary feeding is common might be discouraged by or sceptical of a recommendation that is so different from their usual practices. However, the counter-argument is that simplifying the recommendation to "about six months" may serve as a stimulus to convince mothers to exclusively breast-feed longer than is customary at present.

As was stated at the outset, the benefit : risk ratio of complementary feeding at various
ages may differ depending on the environment. In certain settings (e.g. with very high rates of microbial contamination), the optimal duration of exclusive breast-feeding may be even longer than six months. At present there are insufficient data to evaluate this. Beyond six months, however, most infants are beginning to explore their environment and are thus likely to be exposed to microbial contaminants through soil, etc. even if they are not given complementary foods. Thus it seems reasonable to use the wording "about six months".

It is also important to reiterate that the above discussion refers to the appropriate age of introduction of complementary foods to infants who have been exclusively breast-fed during the first four months of life. An underlying assumption of this document is that there is a supportive environment for breast-feeding, or that every effort is underway to develop and restore breast-feeding cultures. Infants who are not exclusively breast-fed for as long as is recommended need to be fed a diet with a consistency appropriate for age and neurological development. The diet should also possess a nutrient density and bioavailability at least as high as that of human milk.

2.3 Optimal duration of breast-feeding

2.3.1 Current recommendations

The current recommendation of the World Health Organization is that, after the initial period of exclusive breast-feeding, "children should continue to be breastfed for up to two years of age or beyond, while receiving nutritionally adequate and safe complementary foods" (WHO, 1995b). In an earlier document, the wording was somewhat more specific about the minimum desired duration of breast-feeding and stated that "children should be breastfed for at least one year and preferably for up to two years of age or beyond" (WHO, 1991). The recommendation that infants be breast-fed for at least the first year of life is generally echoed by other professional organizations (American Academy of Pediatrics, Committee on Nutrition, 1992). However, the impact of breast-feeding beyond 12 months has been a topic of some controversy. Because this theme has been reviewed recently (Prentice, 1991; Grummer-Strawn, 1993), this section will only briefly present the key issues in the debate.

2.3.2 Nutritional and health impact for the child of breast-feeding beyond 12 months

Although the volume of breast-milk consumed declines as complementary foods are added to the infant's diet, and the milk concentrations of several nutrients decrease during the first 12 months postpartum (particularly protein, iron and zinc), breast milk continues to make an important nutritional contribution well beyond the first year of life. Depending on the population, breast milk provides roughly one-third to two-thirds of average total energy intake towards the end of the first year (Prentice, 1991; Heinig et al., 1993a). Because it is relatively high in fat compared to most complementary foods, breast milk is a key source
of both energy and essential fatty acids. When the complementary foods available are low in fat, breast-milk fat may be critical for utilization of pro-vitamin A carotenoids from foods (see section 4.5.2). Likewise, the contribution of certain micronutrients from breast milk may be substantial. For example, in the Gambia the proportion of total nutrient intake provided by breast milk at 15-18 months of age was 70% for vitamin A, 40% for calcium, and 37% for riboflavin (Prentice & Paul, 1990). The importance of continued breast-feeding for prevention of vitamin A deficiency between 12 and 36 months of age has been demonstrated in several case-control studies (West et al., 1986; Mahalanabis, 1991).

The nutritional impact of breast-feeding is likely to be most important during periods of illness. As mentioned above, breast-milk intake is usually maintained during episodes of diarrhoea and fever whereas the infant's appetite for other foods diminishes (Brown et al., 1990; Brown, Creed de Kanashiro & Dewey, 1995). Breast-feeding is thus a critical factor in preventing dehydration and providing key nutrients for recovery from infections. Some of the digestive enzymes, hormones and growth factors that are found in human milk may also be of particular importance during recovery from malnutrition or illness, especially when the child's gut function has been affected (Prentice, 1991).

Several non-nutritional aspects of breast-feeding are also likely to enhance infant health after the first year of life. It is well-known that the duration of breast-feeding is associated with the delay in maternal fertility postpartum (Howie & McNeilly, 1982; Habicht et al., 1985). In populations that do not use modern contraception, breast-feeding for 2 years or more is thus related to a longer average birth interval, which has a positive impact on child health (Mudkhedkar & Shah, 1976). Although the protective effect of breast-feeding against infections diminishes with age and with the introduction of other foods, there is evidence that morbidity and mortality rates remain lower in children who continue to be breast-fed up to 2 to 3 years of age. This has been found to be the case in many (Feachem & Koblinsky, 1984; Briend & Bari, 1989; Mølbak et al., 1994) though not all (Plank & Milanesi, 1973; Victora et al., 1987; Rao & Kanade, 1992) developing country settings. In the most recent study (Mølbak et al., 1994), conducted in Guinea-Bissau with a sample of 849 children, the adjusted mortality rate for weaned children 12-35 months of age was 3.5 times higher than that of their breast-fed peers. Many of the antimicrobial constituents of human milk, such as secretory IgA, are still present in considerable amounts in the second year of lactation and are thought to retain at least a portion of their anti-infective properties (Prentice et al., 1984; Prentice et al., 1989).

The impact of breast-feeding on infant appetite and growth after the first 12 months has been a controversial issue. In developing countries, some observational studies have shown a positive association between breast-feeding in the second and third years of life and child anthropometric status (Briend, Wojtyniak & Rowland, 1988; Taren & Chen, 1993), but others have shown a negative relationship (Victora et al., 1984; Brakohiapa et al., 1988; Nube & Asenso-Okyere, 1996). There are several potential explanations for the latter findings. First, the associations could be indirect, i.e. due to confounding variables such as socioeconomic status. In many developing countries, poor women tend to breast-
feed longer than those who are wealthier, which could account for the link between long-term breast-feeding and lower infant anthropometric status. However, in some cases this association is still apparent even after controlling for potentially confounding variables (Victora et al., 1984; Nube & Asenso-Okyere, 1996). A second explanation is that the inverse relationship reflects reverse causation, i.e. that the decision about when to terminate breast-feeding depends on the characteristics of the child. For example, there is some evidence that larger infants are weaned earlier (Mølbak et al., 1994). Reverse causation could also occur if children who are more dependent breast-feed longer than children who are more independent, and if dependency (perhaps linked to lower activity) leads to slower growth. Alternatively, infants who are initially less interested in complementary foods may breast-feed longer, and their rejection of other foods may lead to nutrient deficiencies and impaired growth. The third possible explanation is that the association is truly causal, and that long-term breast-feeding adversely affects infant appetite and growth. Bentley et al. (1993) observed that infants who were breast-fed after 12 months had a lower acceptance of non-breast-milk foods and lower total energy intake than those who had been weaned, although again, this could reflect reverse causality.

The only satisfactory way to distinguish among these explanations is through a randomized intervention trial. However, this raises both ethical and practical dilemmas. A study in Ghana (Brakohiapa et al., 1988) included an intervention in which 10 malnourished children 12-24 months of age were weaned abruptly and 5 malnourished children of the same age continued to receive breast milk. Energy and protein intakes were reported to increase significantly after weaning in the former group. However, there were numerous limitations to this study. Most importantly, groups were not randomly assigned but were based on whether the mother wished to stop breast-feeding. In addition, it was unclear whether the advice given to mothers about complementary feeding was similar in the two groups. Because of these and other flaws, the results of the study are difficult to interpret.

Aside from a randomized intervention trial, the next best approach to this question is to collect longitudinal data on intake, growth and morbidity of infants both before and after termination of breast-feeding in the second or third year of life. Data of this nature have recently been published by Mølbak et al. (1994), who found that there was no change in weight-for-age Z-score after weaning, but the incidence of diarrhoea increased by a factor of 1.45. The authors concluded that the benefits of breast-feeding are still evident in the second and third years of life. A similar analysis has been conducted using data from an affluent United States sample in which all of the subjects were breast-fed for at least 12 months (Dewey, Wesseling & Heinig, 1995). After adjusting for expected changes in growth velocity with age, weight gain increased significantly in the three months after breast-feeding ceased, but there was no change in length gain. This finding was consistent with cross-sectional analyses showing that infants who stopped breast-feeding before 18 months gained more weight, but not length, from 12 to 24 months than infants who breast-fed for longer than 18 months. The latter group preferred breast milk over solid foods even in the first year of life, suggesting that infants who are less interested in complementary foods are breast-fed longer. In affluent populations, it is debatable whether slower weight
gain in the second year of life (in the absence of any impact on linear growth, thus implying less fat deposition) is a positive or a negative effect of breast-feeding; given the relatively high prevalence of overweight even among young children in countries such as the United States of America. When inadequate weight gain is of concern, the most appropriate course of action might be to encourage greater consumption of complementary foods (e.g. by breast-feeding after meals rather than before during the second year of life), rather than to terminate breast-feeding (King & Burgess, 1993).

2.3.3 Long-term consequences of breast-feeding beyond 12 months

A new controversy has arisen over whether long-term breast-feeding is associated with the risk of chronic diseases later in life. In a follow-up study of men and women born during 1911 to 1930 in England, men who had been weaned after 1 year of age and those not breast-fed at all had higher serum concentrations of total and low density lipoprotein cholesterol and higher mortality rates from ischemic heart disease than those who had been breast-fed for less than 1 year (Fall et al., 1992). The results were adjusted for social class, but not for lifestyle factors such as diet and exercise. These relationships were not observed in women (Osmond et al., 1993). In a study conducted in the United States of America, duration of breast-feeding was not associated with later mortality from cardiovascular disease or cancer in either men or women, but was related to reduced mortality from injuries in men (Wingard et al., 1994). Given the discrepancy in results, further research is clearly needed to understand the potential relationships between long-term breast-feeding and later health outcomes (Fall, 1992).

2.3.4 Summary

The optimal duration of breast-feeding most likely depends on the characteristics of the mother and child. In affluent populations, long-term breast-feeding is more common among women who are well-educated and can afford good quality complementary foods (Prentice, 1991). Thus, there is little risk of nutrient deficiencies unless the parents are overly restrictive about the types of foods given or the child is very dependent on the breast. The evidence from affluent populations suggests that there is no negative impact on linear growth of continued breast-feeding past 12 months. In developing countries, there is considerable evidence to suggest that long-term breast-feeding can be beneficial by providing a source of key nutrients, increasing birth spacing, and protecting against both the incidence of infections and their adverse nutritional impact. There is a high likelihood that the negative associations with growth status reported by some investigators are due to confounding factors or reverse causation. Therefore, the current recommendation to breast-feed "up to two years of age or beyond" seems appropriate with respect to infant outcomes. In malnourished mothers, maternal dietary supplementation may be advisable, both to optimize breast-milk nutrient levels and to prevent maternal depletion. Nonetheless, if long-term breast-feeding increases the inter-birth interval, it may be less nutritionally demanding than a closely spaced subsequent pregnancy. Thus, there may be advantages of long-term breast-feeding for the mother as well as the infant.