WEANING
PRACTICES IN THE DEVELOPING COUNTRIES
RECOMMENDATIONS AND PROGRAM IMPLICATIONS

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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Infant Feeding and Weaning Practices in Developing Countries</td>
<td></td>
</tr>
<tr>
<td>Breast Feeding Practices</td>
<td>5</td>
</tr>
<tr>
<td>Supplementary Milk Feeding</td>
<td>7</td>
</tr>
<tr>
<td>Initiation of Solids</td>
<td>8</td>
</tr>
<tr>
<td>Adequacy of Exclusive Breast Feeding</td>
<td>14</td>
</tr>
<tr>
<td>Contamination of Weaning Foods</td>
<td>16</td>
</tr>
<tr>
<td>Energy Density and Bulk of Weaning Foods</td>
<td>20</td>
</tr>
<tr>
<td>Micronutrient Content of Weaning Foods</td>
<td>26</td>
</tr>
<tr>
<td>Recommendations for Weaning</td>
<td>28</td>
</tr>
<tr>
<td>Research Needs Related to Weaning in Developing Countries</td>
<td>30</td>
</tr>
<tr>
<td>Summary</td>
<td>31</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>32</td>
</tr>
<tr>
<td>References</td>
<td>33</td>
</tr>
</tbody>
</table>
INTRODUCTION
The word wean is derived from the Anglo-Saxon wenian meaning "to accustom (as a child) to take food otherwise than by nursing" (1). When and what to introduce as weaning foods has been extensively examined and while the literature is vast, there is little hard scientific data (2). The importance of the question is underscored when one considers the consequences of inappropriate weaning (Table 1). Too early initiation of weaning carries an increased morbidity due to diarrheal and allergic disease, decreased breast milk production and malnutrition. Weaning too late can lead to growth faltering, decreased immune protection, increased diarrheal disease and malnutrition. Inappropriate choice of weaning foods can lead to protein caloric malnutrition and an array of micro-nutrient deficiencies. Thus what length of time can safely lapse before complementary foods are introduced, when do the benefits outweigh the risks and what available foods are the most appropriate for weaning are important questions (3,4).

The first year of the life is characterized by rapid growth and changes in body composition, with most healthy infants doubling their birth weight by 6 months and tripling it by 1 year of age. To meet the demands for growth and development, an adequate intake of energy and a variety of nutrients is required. The progression from breast milk to solid food is based on the infant's nutrient requirements for growth, physiologic maturation, developmental stages and cultural influences (5). Weaning practices are considerably different in various parts of the world, and whether these diverse patterns conform to what is optimal is unknown (3,4). Despite the broad range of cultures and diversity of actual weaning practices, there is remarkable consistency between published recommendations for weaning worldwide (6-16a). The primary scientific data upon which current recommendations are based include nutritional need, physiologic maturation and behavioral and developmental aspects of infant feeding, and are summarized in Table 2 (16b). During the first four months of life, breast milk alone provides optimal nutrition for the rapidly growing
young infant (10,17-21). As the infants' physical and developmental capacities mature, solid foods are introduced into the diet and the composition and consistency advanced so that by approximately twelve months of age the infant is eating a variety of foods from a mixed diet. Thus infant feeding should be considered in three overlapping periods. (1) The nursing period constitutes the first four months of life during which time exclusive breast feeding is recommended. (2) The weaning period, when beginning at 4 months and no later than 6 months, foods other than breast milk or formula are introduced into the diet. The introduction of a variety of foods should occur throughout this period so that by the end of the first year, the infant is consuming enough variety to ensure an adequate intake of all nutrients. (3) Finally, a modified adult diet, when the infant or toddler is consuming foods from the family’s diet, but that are age-appropriate (11,12,15,16,22,23).
<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controversy surrounding weaning onset</strong></td>
</tr>
</tbody>
</table>

**Too Early:**
- Increased diarrheal and allergic disease
- Decreased breast milk production
- Malnutrition

**Ideal**
- Appropriately timed
- Nutritionally adequate
- Hygienically prepared
- Culturally appropriate

**Too late:**
- Growth failure
- Depressed immunity
- Increased diarrheal disease
- Malnutrition
- Micronutrient deficiencies
### TABLE II. Basis of Weaning Recommendations

<table>
<thead>
<tr>
<th>Nutritional Need</th>
<th>Weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birth to 4 months</strong></td>
<td><strong>Four to 12 months</strong></td>
</tr>
<tr>
<td>- Appropriate calorie/protein ratio in infancy</td>
<td>- Breast milk volume become inadequate (700-970 ml/day) at 3-6 months</td>
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<tr>
<td>- Increased bioavailability (zinc, iron, vitamin A)</td>
<td>- Nutrients of public health concern to be emphasized in weaning foods are calories, protein, zinc, iron, vitamin D, vitamin A</td>
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<tr>
<td><strong>Physiologic Maturation</strong></td>
<td><strong>Increased concentrating and excretory capacity</strong></td>
</tr>
<tr>
<td><strong>Renal function capacity</strong></td>
<td></td>
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<tr>
<td>- Highly anabolic state, Low renal solute load of breastmilk</td>
<td></td>
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<tr>
<td>- Low concentrating and excretory capacity</td>
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<tr>
<td><strong>Gastrointestinal function</strong></td>
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<tr>
<td>- Immune factors (SIgA, lactoferrin, lysozymes)</td>
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<tr>
<td>- Enzymes (breastmilk amylase, lipase), Taurine</td>
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<tr>
<td>- Growth factors (peptides, nucleotides, IGF-1, cortisol, thyroxine, insulin)</td>
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<tr>
<td><strong>Developmental feeding issues</strong></td>
<td></td>
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<tr>
<td>- Rooting, Sucking, Swallowing</td>
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<tr>
<td>- Extrusion reflex</td>
<td>- Diminished extrusion reflex (4 months)</td>
</tr>
<tr>
<td></td>
<td>- Development of head, trunk, gross and fine motor control (4-12 months)</td>
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<td></td>
<td>- Development of exploratory behavior</td>
</tr>
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<td></td>
<td>- Manual dexterity (12-36 months)</td>
</tr>
</tbody>
</table>
INFANT FEEDING AND WEANING PRACTICES IN DEVELOPING COUNTRIES

This section reviews data on infant feeding practices in developing countries, in order to answer the following questions related to weaning:

1) What length of time can safely lapse before complementary foods are introduced.
2) When do the benefits of adding supplementary and/or complementary foods outweigh the risks.
3) What culturally acceptable foods are the most appropriate.

Breast Feeding Practices:
Breast feeding remains the first and preferred method of infant feeding by the majority of Pakistani women, as with women in most developing countries around the world (24-29). However, inappropriate practices such as delaying initiation of breast feeding till the second or third day of life, discarding of colostrum and the provision of prelacteal feeds may all have a negative impact on lactation (30-34).

Child survival strategies usually recommend exclusive breast feeding for the first four months of life (35-36) but reports on child feeding practices from around the world show that exclusive breast feeding is rare and that early supplementation with water and other fluids is common. Nagra et al from Faisalabad, Pakistan report that of 916 infants followed from birth to 12 months of age, 60% were receiving supplementary milk feeds by 3 months of age (37). In another study of a poor urban population in Lahore; Pakistan, Jall et al report that 50% of the breast fed infants were receiving nutritive and/or non nutritive supplements by one month of age (38). The pattern of early supplementation is not restricted to urban mothers, since Ashraf et al report that only 9% of 1476 infants from various levels of urbanization and income - village, peri-urban slum, urban slum and urban upper middle class, were exclusively breast fed for the first four months and that the bottle was used to feed milk, gruels, water and other fluids to 82% of rural; 90% of peri-urban slums and
100% of the urban slums and middle class infants by one month (39). Even in Gilgit, Pakistan where environmental temperatures are relatively low, mothers insisted that their infants needed extra water even when solely breast fed. Only 4% of the infants reported to have frequent diarrhea and 10% of those with some degree of malnutrition were exclusively breast fed for 4 months (40). There are similar reports of early addition of fluids from other developing countries as well. A report from Saudi Arabia (41) indicates that 75% of 2196 mothers, whether from rural or low, middle and privileged urban class were giving water to their infants at 3 days of age. Early addition of water, tea and other non nutritive liquids to breast milk was common in 3000 infants in the Philippines followed longitudinally through infancy (42). However, studies from Jamaica, Peru, Argentina and India have documented the ability of exclusively breast fed infants to maintain adequate hydration status even in warm climates (43-46). The 78 infants in the four studies ranged in age from less than one month to six months. The home temperatures varied from 23.5°C at night to 39°C during the day, with a relative humidity of 49 to 96%. The maximum urine osmolarity reported was 468 mmol/L. However, when the infant is stressed by diarrhoea, vomiting or fever which result in a decrease in urine output, the kidneys may fail to excrete the osmotic load provided even by human milk and ORS solutions may be required if dehydration is to be prevented.

It is not surprising that water in some form is given very early to infants, since in-depth interviews with health care providers from different areas in Pakistan showed that they universally and adamantly believe that neonates and infants require additional water for survival and no one seems to be aware that use of a bottle even for feeding water interferes with breast feeding (47) in addition to increasing the risk of contamination.

In countries where safe drinking water is available and environmental hygiene is good, the additional water may not do much harm. However in developing countries where drinking water is generally contaminated and environmental hygiene is poor,
exclusive breast feeding may well protect the infant since studies have shown that addition of any supplementary fluid greatly increases the risk of diarrhea and respiratory infection (42,48,49). One needs to bear this in mind when assessing the growth performance of so called "breast fed" infants since they are rarely exclusively breast fed. The feeding of non-nutritive fluids via a bottle in addition to having a negative impact on lactation would result in an exposure to pathogens which may cause infections which in turn would affect growth.

**Supplementary Milk Feeding**

Addition of supplementary feeds has been reported to result in a sharp decline in suckling frequency and duration which is correlated with a decline in mean serum prolactin levels (50). Fear of insufficient milk production leads poor mothers in developing countries to initiate supplementary milk feeding, generally cow or buffalo milk which is invariably diluted to make it qualitatively similar to breast milk. Fifty percent of the 910 infants studied by Jalil et al had supplementary milk started due to perceived milk insufficiency by 1 month of age (38). Khan and Lambert report that the mean age of starting bottle feeding was 50 days for a group of 252 infants from Karachi and 50% of all infants received complementary bottle feeds in the first year. It should be noted that 16% of the mothers stated that they had been told to bottle feed by their doctors (51). Milk was also reported as the first supplementary food given by 32% of mothers from a low income urban settlement in Karachi (52). Fifteen percent of the rural mothers and 22% of the urban low income mothers included in the National Nutrition Survey (25) reported giving their infants supplementary milk feeds due to inadequate volume of breast milk. Similar findings have been reported from Turkey, Indonesia, Malaysia, Kenya and various parts of India (53-59).

The addition of supplementary milk to the diets of young infants in developing countries is not without risk since the milk may be diluted with unsafe drinking water and bottle hygiene is generally poor. In fact Popkins et al in a study from the
Phillipines indicate that the likelihood of diarrhea increases 4.7 to 13.1 times depending on the age of the infant when nutritive liquids are added (42). A longitudinal study from India also shows that infants given supplementary milk in addition to breast feeding had 11.2 episodes of diarrhea/year as compared to 4.06 episodes/child/year for the solely breast fed group (60). In a study of dietary risk factors associated with acute and persistent diarrhea in Karachi 35% of the mothers of the children with diarrhea listed poor lactation as the reasons for adding supplementary milk feeds (61). In Gilgit as well, significantly more children with frequent diarrhea (8.2%) and malnutrition (5-8%) were given supplementary milk as compared to the healthy controls (3.4%). A common reason cited for starting the supplementary milk feeds was insufficient breast milk (40). Most health workers surveyed recently in Pakistan recommend that mothers give "other milk" in addition to breast milk by 4 months (47) but the quantity of milk given is usually inadequate. A review of several studies from India shows that infants from low and low middle income families were receiving only 25-300 ml supplemental milk/day (26).

Supplementation was universally offered as a solution to the "insufficient milk" syndrome by health workers in a survey in Pakistan and except for the traditional birth attendants (TBAs) in rural NWFP of Pakistan, TBA see no harm in feeding the infant milk and other fluids via bottles (47). Similarly in a survey of factors promoting satisfactory breast feeding in teaching hospitals in Indonesia, no mothers and very few health care providers mentioned factors affecting adequate milk supply - frequent suckling, relaxation and support (62). Delivery in a health care facility has also been reported to be associated with early milk supplementation (63-64).

Initiation of Solids
The evidence relating to age at initiation of semi solids and solids is not clear. Studies from developing countries reported in the 60's and 70's indicate a relatively late age at which solids are introduced. The Micro Nutrient Survey of Pakistan, conducted in 1976-1977 reports that more than 50% of the children did not receive
any food besides milk and other fluids during the first year of life and 10% did not receive any solids till their second birthday (65).

According to the National Nutrition Survey (25) 68% of children 7-9 months of age consumed no other food than milk and even among 12-17 month olds, 30-50% received no semi-solid or solids. Introduction of solid foods was even later in the rural areas of Pakistan. Whereas a study conducted in 1985 in Baluchistan reports the average age for starting solids in various regions of Baluchistan to be 8.3 months (66). Similarly the mean age of starting solids ranged from 6.8 months for families which did not have any malnourished children to 8.7 months for families that had at least one child under 5 years who was malnourished in a study from Mansera (67).

In Karachi as well, age at weaning was correlated to nutritional status, although 64.5% of the infants in the survey were given solid foods before the age of 6 months, there was a sizeable proportion in whom introduction of solids was delayed till the second half of infancy, with a concomitant increase in the percentage of children who were malnourished in this group 71.5% as compared to less than 30% in the former (51). In Gilgit the mean age at weaning for healthy controls was 6.3 months as compared to 5.8 months for those children reported to have frequent episodes of diarrhea (40).

The pattern with regards to age at initiation of solids appears to be changing. Sharif in 1969 reported the mean age at starting solids to be 8 months (68) whereas studies in the 80's report that by 3-4 months upto 42% of the infants were receiving solids (69-70). Results of focus group discussions with mothers from various areas in Pakistan also indicates that there is a trend towards earlier introduction of solids by about 4 months of age (71).
A similar trend can be seen in the review of literature on infant feeding practices in India. Introduction of solid foods was late in the low income groups in and around Delhi, with up to 55% of the infants not receiving solids till 9 months of age (26). In Bombay and adjoining rural areas only 18% of the 1166 infants surveyed were receiving solids at 6 months of age (59). Of the 1200 urban and 1000 rural infants surveyed in the Jammu and Kashmir area only 5% of the urban and 1% of the rural infants were receiving solids at 6 months (72) but a more recent study by Chitkara and Gupta reports that 81% of the infants born at a hospital in Delhi and followed longitudinally, received solids by 6 months of age (60).

Data on length of exclusive breast feeding and on age at starting solids should be examined carefully. Since the mothers understanding of the questions being asked may be different to that of the researcher. For example herbal teas are frequently given to infants for colic and digestive problems in many parts of the world, however mothers do not report it when asked to list what the infant was fed, as they view the tea as medicine rather than food (73). Similarly ethnographic studies have shown that often the mother does not list foods given to an infant as snacks or to "nibble on" in between meals; when asked what the child eats, as she equates the term "eat" with meal time foods (55,74).

Regardless of when solids are started, it appears that the food offered to the child is often inadequate in amount and nutritional value. In Baluchistan very few mothers prepare special foods for the child. In a survey of 90 rural households in Baluchistan most mothers gave their children roti and/or biscuits, followed by potato and rice from the family pot (66). Similarly in another study from Karachi only 17% of the mothers prepared food especially for the child. Biscuits were commonly the first weaning food, while older infants were given kitchri or rice cooked for the family or roti soaked in tea (52). In the urban slums of Karachi as well as in some rural areas roti or chapatti (flat unleavened bread) soaked in tea is a popular weaning food (personal observation).
As part of the National Nutrition Survey, 6000 children under 2 years were surveyed, 62% of the 7-12 month old were receiving roti, surprisingly an equal percent were reported to be receiving "curry". Approximately 56% were receiving biscuits or rusks and 48-53% were said to be given rice or rice based dishes such as kheer. Significantly, 32% of the mothers said they decreased the child's intake of roti when he had diarrhea and 21% said they gave increased amounts of kitchri (25). A more recent study of 741 children in Pakistan reported that 50% of the mothers who gave kitchri to their children continued to do so during diarrhea. Mothers in this study considered banana, kitchri, yogurt and boiled rice as "good" foods for children with diarrhea whereas chapati, curry and melon were considered harmful (75). Thus the child whose major weaning food is roti is at greater risk of inadequate intake during episodes of diarrhea, whereas when the family's staple food is rice, increased amounts of kitchri can protect the child from the negative impact on growth that may be expected as a result of diarrheal episodes.

Data from several sources (37,51,57,69) indicate that when weaning starts relatively early i.e. about 6 months of age, the most common solid foods are kitchri, cereal gruels, boiled rice with milk and banana. When solids are introduced towards the second half of infancy, chapatti, chapatti soaked in milk or tea and chorri (crumbled chapatti with sugar and fat added) are the foods most commonly given, possibly due to the fact that chapatti based meals are relatively more difficult for a young child to eat. In fact Cowan states that the struggle to make a 5-6 month infant eat chapattles, even if they are crumbled in tea, is regarded by the mother as an exercise of little use (76).

In contrast to this the preferred weaning food for infants in Gilgit is a thick gruel (Dowdo) made from wheat flour and milk. Several variations of Dowdo exist, one which is particularly energy dense and nutritious is made with an equal mixture of ground apricot seed and wheat flour, however mothers do not consider this particular dowdo suitable for feeding infants and young children (40).
Since regional variations in availability and acceptability of different foods for feeding young children exist, every effort should be made to identify food available in different communities in Pakistan which can be modified for use as a weaning food.

Commercially available cereals are also used even by mothers from low income groups. Thirty seven percent of the 252 mothers in one study in Karachi mentioned "Farex" as one of the first solids given and even in the remote village in Gilgit 12 to 22% of mothers in different groups mentioned Farex (40,51). Gopujkar reports from India as well that use of commercial cereals varied from 22-39% in the city and 5-12% in rural areas (77). The reasons for using these cereals were either convenience or that the mothers perceive them to be "better" for the child than the home prepared weaning foods. Again health care providers may be responsible for this perception. For example an article in a major newspaper in Pakistan written by a senior pediatrician, list "Cerelac" cereals as the first food in his list of potential weaning foods, followed by kitchri, banana, rice etc. This makes mothers believe that home prepared foods are second rate foods (78).

There is little or no quantitative data available regarding intake of weaning foods in Pakistan. In a report on feeding practices in the "katchi abadis" in Karachi, Mull states that there appears to be no strong tradition either of monitoring what the child eats or of encouraging children to eat. After a child can sit up and reach for food, particularly when he is able to walk, mothers tend to lose track of what he ate (79). Secondly there seems to be little connection in the mothers mind between growth and food and in fact weak children are likely to be given less food since it is believed that the strength of the food had to match the strength of the body (40,79,80). Data from other developing countries indicate that the quantity of supplementary foods given to infants is generally inadequate.
A study from Bangladesh reports that 54% of infants between 5-12 months and 100% of the children between 24-30 months received cereals but the mean intake was only 35 g/day in the younger age group and 94 g/day in the older age group with boys receiving significantly more than girls. Mean intakes of other foods consumed by infants less than 12 months were 13g sugar, 18g roots and tubers, 136g dairy products, 86g fruit, 2g legumes and seeds, 8g fish, 1g fat, in addition to 632g breast milk. The total calories provided was approximately 70 k cal/kg/day as compared to the recommended intake of 95-102 k cal/kg/day for the age group of 5-12 months. None of the children in this age group received meat, eggs or green leafy vegetables (81).

Van Steen Bergen et al from Indonesia report that in late infancy the infants consumed only 45 g rice in addition to breast milk which increased to 55 g by one year of age. Apart from rice, banana was the only food consumed and that too by only some of the infants. The mean intake was 25 g/day. Older infants did eat egg, fish, fruit and snack/sweets but in small quantities and irregularly (82).

Inadequate intake of complementary foods by Indonesian infants is also reported by Launer et al. The mean intake from meals was 167 k cal/day at the end of early infancy and decreased to 147 k cal/day by the end of late infancy, however intake of snack foods increased from 18 k cal to 59 k cal in the same period (80). In Yemen, biscuits were reported to be the major weaning food but the average intake per day was only 18g providing 73 k cal/day (83).

Shekar reports a larger variety of foods being consumed by infants in India. Foods commonly consumed were rice (80%), cooked vegetables (53%), dal (40%), biscuits (33%) and chapatties (30%) but these supplements were given in inadequate amounts providing 7-120 k cal with a mean of 55 calories/day (84).
When additional milk is available, mothers prefer to use milk as a supplement to breast feeding as indicated by the fact that the mean intake of infants aged 13-24 months in Lucknow was as follows: breast milk 110g, other milk 310g, cereals 17g, pulses 24g, vegetables 3g, fat 3g and meat 0.8g (85).

In general mothers in traditional underprivileged societies appear to find it relatively easy to initiate supplementary fluid feeding. On the other hand either through lack of knowledge of the child's needs, cultural preferences or unavailability of suitable foods, the mother does not feed the child enough solids of adequate nutritional quality.

**ADEQUACY OF EXCLUSIVE BREAST FEEDING**

In order to determine when the energy and nutrients provided by breast milk become inadequate to support adequate growth in the infant Waterlow and Rutishanser (86) analyzed the results of three longitudinal studies from The Gambia, Uganda and Jamaica and report that the rate of gain in both weight and height had began to falter by three months of age. Data from 12 longitudinal or 5 longitudinal studies in which measurements were made at 3 monthly intervals, summarized by Waterlow (87) also indicates that in developing countries growth tends to falter as early as the third month. However all the studies analyzed were done in the 60's and 70's, when there was little awareness of the need for exclusive breast feeding if lactation capacity was to be optimized nor was there the recognition of the fact that addition of water and other non-nutritive fluids increased the risk of diarrhea, which in turn could have a detrimental effect on growth. When exclusive breast feeding is practiced the infants appear to do better. Ahn and Maclean showed that 96 infants of healthy mothers in an upper class community in USA did not need any supplement to exclusive breast feeding for the first 6 months of life in order to grow adequately (88). Similar results are reported from Ludhiana, India for 347 healthy infants with birth weights of 2.5 kg or more who were exclusive breast fed for the first 6 months. Underprivileged mothers, in spite of poverty, poor diet, unhygienic
surroundings and physical labor in the field are able to breast feed satisfactorily 90% of their male infants for 6 months. The growth of these infants was almost identical with the 50 percentile of Harvard standards for the entire 6 months and in fact these infants did better than those who had supplementary milk. The female infants however did not fare so well and only about 73% were able to attain adequate growth regardless of whether they were exclusively breast fed or had supplementary milk added (89). These results indicate two important points. First, that adequate growth can be maintained by exclusively breast fed infants in poor communities, Secondly, that the mothers attitude to the infant also has a strong influence on her ability to successfully breast feed her infant, in short the constraint may be emotional rather than physiological when breast fed infants show growth faltering.

One also needs to keep in mind that all current major growth standards are based on data collected in the 50's and early 60's and are derived from predominantly formula fed infants with early initiation of solids, a group we would now consider over fed; therefore a growth curve from predominantly breast fed infants may identify with greater accuracy when growth begins to falter in developing countries. For example when Kusin et al (90) used the NCHS reference to evaluate growth performance of Madurese infants, growth faltering seem to occur at 8-12 weeks, but using the growth of breast fed infants as a reference (91), growth appeared to falter at 20-24 weeks.

Another approach to assessing the adequacy of breast milk is to compare energy intake from breast milk with the recommended energy intake. Whitehead reports that a statistical analysis of the measured energy intakes of both breast and artificially-fed infants from a number of developed countries suggests that instead of slowly decreasing from 120 k cal/kg at birth down to 105 k cal/kg at one year; energy requirements drop much more quickly, reaching 90 k cal/kg or even lower by 6-8 months and increasing again as the infant becomes more mobile (92,93).
Lucas et al also came to the conclusion that the presently recommended energy intake may be higher than the infants actual requirement after studying the intake of both breast and formula fed infants using the doubly labeled water method for assessing milk intake. The 11 week old infants consumed 528 kcal per day which was associated with normal growth (94). If the RDA for energy over estimates the infants energy requirement, than it is possible that breast milk outputs reported from around the world are in fact adequate to support growth for at least four months and under ideal conditions possibly 6 months.

One must also bear in mind that from the data in developing countries it is almost impossible to separate the effects of inadequate intake from that of infections on the growth of infants. Even predominantly breast fed infants suffer more morbidity in developing countries than their counterparts raised in more hygienic conditions.

Thus it is not possible to identify a single point in time when solids should be added to the infants diet. The onset of weaning must vary from infant to infant depending partly on the lactational capacity of the mothers and the nutrient needs of her child.

**CONTAMINATION OF WEANING FOODS**
Regardless of when supplementary feeds or solids are added to the diet, the weaning period is a crucial period in a child's life. The process of weaning may not be of major significance for the infants growth and health in populations that have access to food which is adequate in terms of quality and quantity and sanitary conditions are satisfactory but where poverty restrict food availability, knowledge about the infants nutritional needs is poor and environmental sanitation far from satisfactory the weaning period can be a threat to survival.

Studies have shown that diarrheal disease significantly increases at about 6 months of age and this is generally attributed to the increased exposure of the infant to pathogens as a result of initiation of the weaning process. As early as 1974 Rowland
et al reported that traditional weaning foods used for young infants in West Africa could be as hazardous, bacteriologically as commercial milk products (95) and it has been suggested that the number of pathogens required to induce illness may be less if they are ingested in food rather than in fluids, since food may protect the pathogens during their passage through the acidic environment of the stomach (96).

The recommended safe level for coliform counts is less than 50 organisms/100 ml water (97) however contamination of well water considerably above "safe" levels has been reported from Bangladesh which contained 10^1-10^2 fecal coliform/ml, Kenya with counts of 10^1-10^5/ml of drinking water and India where counts were regularly around 10^2/ml of drinking water in Madras (98-100).

The situation with regard to contamination of drinking water is undoubtedly similar in Pakistan. Thus preparation of even fresh cooked foods which have to be diluted with water in order to make it the right consistency for feeding a 4 month infant, will result in a contaminated weaning food.

Black et al reported that 41% of the samples of food fed to weaning children contained significant amounts of E. Coli and that milk and foods especially made for children were more frequently contaminated and had a heavier contamination of E. Coli than boiled rice. Although water was more frequently contaminated with E. Coli than food, the colony counts in foods were up to 10 times greater than in water (101). The proportion of a child's food samples that contained E Coli was significantly related to that child's incidence of diarrhea associated with ETEC, the most frequent enteropathogens causing diarrhea in the study children (102).

Another study from Bangladesh showed that "wet foods" such as milk and rice gruels used for feeding infants were more highly contaminated than "dry foods" such as roasted rice, bread and even rice cooked for the family. For the rice gruel (panta bhat) a 10 fold increase in mean counts of fecal coliforms were observed
between storage for 0-4 hours and 16-23 hours. The need to retain the liquid properties of the rice gruel appears to increase contamination to high levels (103).

Similar contamination of weaning food and supplementary water is reported from Thailand. The least contaminated foods were whole rice and rice soups whereas commercial cereals and infant formulas had bacterial counts that were equal to or higher than the counts in premasticated rice. The bacterial count of the infants' water was significantly higher than the family water and there was no significant difference in the bacterial count of boiled water as compared to unboiled water, possibly due to poor cleaning and frequent re-use of the utensils used for feeding the infant (104).

Premastication of foods fed to infants has been observed in some rural populations in Pakistan as well. Premastication, although a simple way of homogenizing foods for immediate consumption by the infant, can add mouth organisms such as tubercle bacilli, upper respiratory tract virus as well as fecal coliform to the food.

Elegbe and Ojofeitimi examined 415 food specimens ranging from breast milk, other milks, gruels, rice, wheat and beans and report that all samples except breast milk had detectable bacteria. Further, the stool cultures of 26 children who were 9 months of age or younger showed lower colony counts in those who were exclusively breastfed than those who were fed other foods as well. The most frequently recovered bacteria were enteropathogenic E Coli and Staphylococcus aureus (105).

The contamination with coliforms reported for rice and tortillas (106) after cooking is of relevance to the weaning of Pakistani infants since rice, kitchri and roti are commonly used weaning foods. In general these foods are not prepared fresh for the child, but given from foods prepared once a day for the family. Thus the risk of the Pakistani infant consuming highly contaminated food which would result in him experiencing diarrhea is high.
Improved hygiene during food preparation and storage is essential but hard to achieve in deprived communities and advice to mothers to cook fresh food for the infant at every meal not very practical when food and fuel are in short supply and the mother is too over-worked to cook several meals a day. Under these circumstances a method to inhibit bacterial growth during storage of infant food could be of considerable benefit to infant health and nutrition.

When bacterial contamination of milk and gruels stored for 8 hours was studied, it was found that biologically acidified milk had lower counts of both staph aureus and B aureus than milk or traditional gruels (95). Fermented milk consumption has been reported to decrease the incidence of Salmonella carrier state (107) and reduce the risk of travellers diarrhea caused by entero-toxigenic E Coli (108). Volatile fatty acids produced by lactic acid bacteria may be responsible for controlling the colonization of the gut by Shigella and E. Coli (109).

Yogurt or dahi is a commonly used food product in various parts of Pakistan and in some ethnic communities is used for the dietary management of diarrhea in children as well as adults (personal observation). Feeding yogurt instead of milk to children with acute and persistent diarrhea has been reported to have a favourable impact on clinical outcome (110,112). The favourable effect of yogurt can be explained by the 44% decrease in lactose content of yogurt compared to milk due to the fermentation process (112) plus the more efficient lactose digestion due to the intraluminal activity of the microbial B-galactosidase contained in yogurt (113). The prevalence of lactose intolerance in infants has been reported to range from 40 to 50 percent in various developing countries (114). Mothers in Pakistan resort to supplementary milk feeding of their infants quite early, the possibility of using dahi as a source of supplementary milk in the community needs to be studied in terms of cultural acceptability as well as its benefits with regard to decreased diarrhea due to contamination and/or lactose intolerance.
Fermentation of cereals have also been reported to inhibit diarrheal pathogens. In a study from Ghana unfermented and fermented maize dough weaning foods prepared by mothers were examined for gram negative bacilli (GNB) immediately after preparation and during storage to assess the antimicrobial effects of fermentation. GNB were cultured from all samples of unfermented dough and 31% of the fermented dough. Porridge made from unfermented dough had significantly higher levels of GNB especially after storage for 6 hours (115). Fermented dough is used in many parts of Pakistan for making "tandoori nan". The possibility of using such fermented dough for making weaning foods needs to be explored especially for those areas where roti and not rice is the staple food. This may be particularly advantageous since the fermentation process may add nutrients such as vitamin B₁₂ not present in the original dough (116).

**ENERGY DENSITY AND BULK OF WEANING FOODS**

The faltering of growth whether it occurs at 4 months or 6 months requires the addition of a food equivalent to the energy density of breast milk. All traditional weaning foods tend to be in the form of a gruel made from the local staple. Because of the natural property of the starch granule which swells on boiling in water and gets gelatinized on cooling, the gruel increases in viscosity, whereas physiologically the young infant can only swallow gruel of a fluid consistency without choking (117). When water is added to make it more liquid, the energy and other nutrient density of the gruel declines. Most traditional weaning foods are reported to contain 5-10% dry matter with an energy density of 0.2-0.4 k cal/gram (118). It is estimated that a 5-6 month infant consumes an average of 700 ml breast milk per day which provides 455 k cal (119). According to data derived from FAO/WHO/UNH Technical Report on Energy and Protein Requirement (120), the 5-6 month old infant requires 730 k cal/day. In order to obtain the additional 275 k cal from the traditional gruel the infant would have to consume 1375 ml of the gruel. Given that the gastric capacity at this age is about 228 ml (119) this obviously becomes a difficult task. Most mothers in developing countries are hard pressed
to take the time to spoon feed their young infants even twice a day. When only two meals are given in addition to breast feeding the calorie density of the complementary food needs to be at least 0.6 k cal/gm so that 228 g (gastric capacity) of food will provide approximately 137 k cal per meal. Increasing the proportion of flour only makes the gruel too viscous for the infant to swallow, at the temperature at which the gruel is normally eaten i.e. 36-46°C. One way to get around this problem is to add oil to the gruel, in addition to adding calories, it has a dramatic softening effect, producing a liquid gruel at a lower temperature and/or dilution level (121). Figure 1 shows how a pure staple changes quickly from a liquid (A) to a solid (B) as its cools. The undernourished child is a slow eater and finds that as the food thickens his meal becomes increasingly more difficult to swallow. The addition of oil softens the food and it remains a drinkable liquid throughout the typical range of eating temperature, that is, from (C) to (D).

Another method of food preparation which can successfully improve energy intake of small children is that of malting, whereby amylases produced by germination break down the starch molecules (119). The flour from this germinated grain produces a low viscosity gruel with an energy concentration of 0.6-0.8 k cal/gm (122). Figure 2 compares the viscosity of gruels made from unmalted and malted sorghum flour at different levels of concentration. Malted flour produces a low viscosity gruel which has three times the concentration of a gruel of similar consistency made from unmalted flour.

While the process of making amylase rich flour is simple, routine use of germinated flour for preparation of weaning foods is a rather time consuming job and adds to the heavy work load of women in developing countries. For this reason Gopaldas et al suggest the use of the germinated flour as an additive to weaning foods prepared from ungerminated cereals and grains (124).
FIGURE 1: THE RELATIONSHIP BETWEEN TEMPERATURE AND FOOD VISCOSITY WITH AND WITHOUT THE ADDITION OF OIL

Adapted from Church 1977 (112) by Deorden 1980 (121)
VISCOSITY

Solid

Semi-solid

Semi-liquid

Liquid

UNMALTED

MALTLED

Concentration of gruel (%)

FIGURE 2: VISCOSITY OF GRUEL: REDUCTION BY MALTING

Adapted from Brandtzaeg 1979 (124)
by Deorden 1980 (121)
Grinding and mashing of foods such as rice and kitchri (rice-lentil mix) can make energy rich adult foods available to the infant. Kitchri is a commonly used weaning food in the Indo-Pak subcontinent. Dahi or yogurt is also a familiar food, and although not commonly used to feed infants, was successfully used in a study in Karachi to feed infants with persistent diarrhea (110). The composition of the kitchri as used in these studies was as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Rice</td>
<td>59 g</td>
</tr>
<tr>
<td>Mung Dal</td>
<td>30 g</td>
</tr>
<tr>
<td>Oil</td>
<td>10 g</td>
</tr>
<tr>
<td>Salt</td>
<td>1 g</td>
</tr>
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</table>

After cooking to soft stage 100g kitchri weighed 340 g i.e. the water content was approximately 70.5% and the energy density was 1.18 k cal/g.

The consistency of this kitchri was appropriate for feeding children over 12 months of age. In order to make it more appropriate for feeding infants between 6-12 months the kitchri had to be softened further with yogurt in a proportion of 3 parts kitchri to 1 part yogurt. This mixture provided 1.04 k cal/g. In order to get about 836 k cal that the 7-9 month infant requires, the infant would have to consume about 804 g/day. If one were to estimate the gastric capacity at this age to be about 250 g, then 4 feeds of about 200 g would be adequate to supply the energy requirement. If however the infant was also breast fed he would obtain approximately 422 k cal from an average consumption of 650 ml breast milk (119), leaving 414 k cal to be provided by the kitchri-yogurt mix i.e. 398 gms which could be provided easily as 2 meals/day.

The use of yogurt rather than milk to soften the kitchri has two advantages, the bacteriostatic action of the yogurt plus the better digestion of lactose. The yogurt would also provide valuable nutrients namely animal protein, vitamin A, riboflavin and calcium.
In Tanzania preschool children ingesting prepared food with an average energy density of about 1.25 kcal/g were able to meet their estimated daily energy requirement (125). In India, well nourished children consumed a diet with a mean energy density of 1.17 kcal/g while the diet of children with low weights for age had an energy density of only 0.74 kcal/g (126).

Apart from the adequate energy density of kitchri, Hussain and co-workers have shown using the short term nitrogen balance method with 11-20 month infants that the true digestibility of kitchri was 74.6% as compared to 86.1% for a rice-meat mixture. The mean nitrogen retention as percentage of intake of the kitchri was lower (29%) than that of rice meat diet (38.7%), but subjects were in positive nitrogen balance on both diets (127).

Community based studies need to be undertaken to evaluate the acceptability and feasibility of using a kitchri-yogurt mix for feeding young children. Isenalumhe reports that the prevalence of malnutrition in Nigerian infants weaned mainly on maize gruel was significantly greater than those weaned on mainly adult diets, minimally modified by either extra cooking or mashing the food to ease swallowing (128). Since studies from India and Pakistan show that very few mothers prepare foods especially for the young infant modified adult meals may be a viable alternative to traditional or commercial weaning foods.

The modification of kitchri to make it suitable for feeding the young child has already been discussed, however where chapatties or rotlis are the staple food, modifying their use for infant feeding may be a little more difficult and may explain the high use of biscuits as weaning foods in urban as well as some rural areas, since they are relatively easier to crumble into tea or milk to make it suitable for the young child.
MICRONUTRIENT CONTENT OF WEANING FOODS

Apart from the energy and protein content of the weaning diet the micronutrient content of the diet needs to be considered as well. Anemia is one of the most prevalent micronutrient deficiency in the world (129). In a study of 3 urban squatter settlements of Karachi, Molla et al found the prevalence of anemia in 6-12 month infants to be 62% and 82% in 13-24 month old children (130).

Although the iron content of breast milk is only about 0.3 mg/L almost 50% of the iron from breast milk is absorbed as compared to 5-10% from other foods (131). Nonetheless the infant soon needs an additional food source of iron. Cereals traditionally used to supplement breast fed infants have low iron bioavailability. The high phytate content of wheat flour is one of the reasons for the poor bioavailability of iron from foods such as chapatties and rotis. Fermentation of doughs has been reported to decrease their phytate content (132). Chapatti or roti soaked in tea is commonly used as weaning food in Pakistan; the tannic acid in tea is also reported to decrease absorption of iron (131). How much tea is consumed by young infants and how this affects the bioavailability of iron from the foods consumed therefore needs to be studied. Other means of increasing iron bioavailability are the presence of heme iron and/or ascorbic acid along with the meal (133). Meats are generally not included in the infant and young child's diet for a variety of reasons apart from their high cost. In the Karachi study, the mean intake of iron was only 2.04 mg/day for infants 6-24 months of age (134). Thus ways and means of increasing the intake and bioavailability of iron by the young child need to be explored. It may be that for the present the first task should be to improve the mothers diet during pregnancy with regard to iron intake and thus ensure that the infant will be born with adequate stores of iron to meet its needs for the first 6 months of life. Secondly mothers could be encouraged to add green leafy vegetables such as spinach to weaning foods such as kitchri. It should not be too difficult to get the mothers to add vegetables to the kitchri, since the addition of vegetables to rice is
a common practice in many parts of Pakistan. However there are reports that mothers associate the consumption of green leafy vegetables with the incidence of diarrhea (69,135). This may be one reason why green leafy vegetables which are a good source not only of iron but also vitamin A and C are seldom fed to the young child. Health education efforts must address these beliefs if the resistance to using green leafy vegetables is to be overcome. Thirdly, Jelliffe (136) suggests encouraging mothers to use a cooking pot which is made of iron rather than aluminum in order to increase the iron content of food; however how well this inorganic form of iron is absorbed would need to be determined.

Clinical vitamin A deficiency does not appear to be a public health problem in Pakistan since the presence of clinical signs and low serum retinol values is uncommon (137). Molla et al (138) found only 2% of 532 children under 5 years to have serum retinol levels <10 µg/dl however 46% had low values, that is, 10-<20 µg/dl, indicating that marginal vitamin A deficiency is quite prevalent. The mean dietary intake of retinol in those having low serum retinol levels was 362 RE with milk providing 55% of the total intake. This indicates that the consumption of food sources of vitamin A other than milk was poor in this group and that as the child grows older and receives less milk, his vitamin A intake could become inadequate. In view of the reports from around the world, on the association between vitamin A intake and mortality in children, especially with regards to mortality due to measles (139), ways of ensuring an adequate intake of vitamin A especially by the young child who is no longer receiving milk need to be identified. A number of foods rich in vitamin A namely green leafy vegetables, carrots, papaya, mango etc are available in the urban areas of Karachi however mothers fed little or none of these to their young children. The resistance to the use of available foods high in nutrients needs to be understood if health education to improve weaning practices is to be successful.
RECOMMENDATIONS FOR WEANING:

Although many different infant feeding patterns have been recommended in industrialized and developing societies, they all have a common theme based on the nutritional, physiologic and developmental needs of the infant. Current recommendations are outlined in Table 3; important points are:

1. Breast milk should be given exclusively for the first 4 months. In developing countries, breast feeding should be encouraged throughout the first 2 years, even if it provides only a small part of total intake.

2. Beginning at 4 months and no later than 6 months, the infant is gradually introduced to weaning foods. While the order of introduction is not precise and schedules will vary since each infant will progress at his/her own rate, it is generally recommended to (a) Start with small serving sizes of 1-2 teaspoons and gradually increase to 3-4 tablespoons per feeding. (b) Introduce single ingredient foods one at a time, introducing a new food every 4 to 5 days. (c) While a staple food that is calorically dense and adequate in protein is important, variety is essential in providing for complete, nutritional needs. Iron, zinc, vitamin D and vitamin A rich foods should be emphasized. (d) Initially, complementary foods are given once a day, then gradually the frequency is increased so that the infant is eating 2-4 meals per day by about 6 months of age. Infants over 6 months of age need to eat meals and snacks about 4-6 times a day in addition to breast feeding.

3. Food should be cool, covered, clean and cooked. To avoid bacterial contamination, only freshly cooked or freshly peeled or washed foods should be used. The hands of both the food provider and child should be washed before handling food. Cooked foods should not be kept for more than 1-2 hours in hot climates unless they have been thoroughly cooked, can be stored in a very cool place, and kept covered.

28
<table>
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<th>TABLE III</th>
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<tr>
<td><strong>Basic Weaning Recommendations</strong></td>
</tr>
<tr>
<td>Months</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>Breastmilk</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Transtional Period</td>
</tr>
<tr>
<td>Given regularly</td>
</tr>
<tr>
<td>Staple weaning food and other grains</td>
</tr>
<tr>
<td>Soft fruits and vegetables</td>
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<tr>
<td>Meats and other protein rich foods</td>
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4. Throughout the latter half of the first year of life, variety in taste and texture of diet is expanded. As the child approaches 1 year of age, he should be encouraged to feed himself. By 2 years of age, children can eat most foods from the family diet, and should be consuming a varied diet with choices from each of the food groups.

**RESEARCH NEEDS RELATED TO WEANING IN DEVELOPING COUNTRIES**

1. Avoidance of inappropriate early weaning is contingent upon the mother's ability to exclusively breast feed her infant for 4-6 months, research is needed to understand the constraints to exclusive breast feeding and how they can best be overcome.

2. There appears to be no link between food, growth and physical illness in the minds of mothers in poor communities. Weaning education should reinforce the connection between food and growth. Studies are needed to determine how best to design locally appropriate educational messages and the method of their delivery.

3. Studies are needed to explore the use of traditional practices such as fermentation and malting to develop weaning foods low in bulk and bacterial content but of high energy nutrient density.

4. Given the constraints on the mother's time and energy as well as the lack of facilities for special food preparation, studies need to be undertaken to develop techniques to use cooked food available in the home, for the preparation of appropriate weaning foods, such that little or no special cooking is required.
5. Where lack of resources preclude the cooking of fresh foods for each meal, ways to minimize contamination of weaning foods during storage under conditions in the community need to be studied.

6. Given the high prevalence of anemia and the fact that increased intake of animal foods appears unlikely, there is a need to study how the intake of plant foods rich in iron can be increased as well as ways of increasing the bioavailability of iron from plant sources.

7. Data pertaining to weaning practices in Pakistan is inadequate. Studies are required to define in detail the nature of weaning practices in the different regions and ethnic groups in Pakistan. Due to difference in perceptions of the researchers and the people they study, simple cross sectional studies in which mothers are interviewed regarding their practices is usually not sufficient. Longitudinal studies, supplemented by observation and in-depth discussion of practices are needed in order to clearly distinguish between mothers stated beliefs and their actual practices.

SUMMARY
Breast feeding is still practiced by the majority of Pakistani mothers, but exclusive breast feeding, even in the first month is rare. Inappropriate breast feeding practices exist and could be responsible for the widely reported "insufficient milk syndrome" which leads to early milk supplementation, often in the first few months of life, exposing the infants to pathogens. Solids are generally started by the age of 4-6 months, but are inappropriate in form, inadequate in quantity and of poor nutritive quality. There appears to be no awareness on the part of the mother regarding the infants quantitative food needs during the second half of infancy. Milk and weaning foods are likely to be contaminated, thereby resulting in increased diarrheal morbidity and hence impaired growth. However traditional foods and
preparation methods do exist which could be explored as a means of providing Pakistani infants with safe foods of high energy and nutrient density.

Exposure to modern health care systems appears to be associated with decreased duration of exclusive breast feeding, early addition of supplementary milk and use of commercial cereals, therefore educating health care professionals regarding appropriate infant feeding practices must be given utmost priority, along with education for the mother.

Current weaning recommendations are based upon nutritional need, physiologic maturation, and the behavioral and developmental aspects of infant feeding. Inadequate energy and protein intake and deficiencies of iron, zinc, vitamin A, and vitamin D are the most commonly observed nutrient deficiencies during infancy and weaning recommendations have focused on their prevention.

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35


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