

## REVIEW

## Weaning of infants

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The WHO 2001 global recommendation is a one size fits all approach to weaning, an approach which may not take sufficient account of the special needs of some infants and fails to allow for the different problems encountered in the industrialised nations compared with economically developing countries. For the healthy normal birth weight full term infant born in an industrialised country, current research supports the benefit of exclusive breast milk feeding until 4–6 months. Evidence of harm through introducing solid food to these infants earlier than this is weak. Infants should be managed individually according to their needs.

In 2001 the World Health Organisation (WHO) issued a revised global recommendation that mothers should breast feed exclusively for six months.<sup>1</sup> This recommendation is likely to influence national policies on the recommended age for the first introduction of solids, so it is important that paediatricians are aware of the issues and the evidence (or lack of it) on which the WHO recommendation is based. This is the main subject for this review, but other important issues are addressed, such as the influence of early nutrition on short term and later health and the question of whether we should adapt recommendations to take account of the special needs of groups such as low birth weight or atopic infants. In developing countries malnutrition is an important cause of infant mortality and morbidity, and the evidence that the too early introduction of solid food has an important deleterious effect in this context is presented. Finally, the relevance of this evidence to infants born and reared in western industrialised countries is discussed.

## DEFINITIONS

The introduction to solid feeding and the gradual replacement of milk by solid food as the main source of nutrition is the process known as weaning. In its recent publications the WHO uses the term weaning in a more limited sense to indicate complete cessation of breast feeding. Complementary feeding is the provision of any nutrient containing foods or liquids other than breast milk and includes both solid food and infant formula. In the UK the terms “weaning” and “complementary feeding” are sometimes used synonymously to mean infant solid feeding.

## THE IMPORTANCE OF WEANING AGE

The key to understanding infant feeding policy is an appreciation of the scientific evidence on which recommendations for the age for the first introduction of solids rest. Early diet has an immediate effect on the health of infants in economically developing countries because of factors such as the lack of availability of suitable alternatives to breast milk, microbial contamination of foods and fluids, displacement of breast milk by less nutritious alternatives, and the return to fertility associated with the cessation of lactation. In fact there is abundant evidence to support the continuation of exclusive breast feeding in early life to reduce morbidity and mortality among infants in economically developing countries.<sup>2</sup>

In addition, there is an increasing recognition that diet in infancy may have an effect on health throughout childhood and adulthood. For example, a birth cohort study of children from Western Australia<sup>3</sup> has shown a significant reduction in the risk of childhood wheezing associated with exclusive breast feeding for at least four months. Furthermore, observational studies have implicated the ingestion of cows' milk as a trigger factor for insulin dependent diabetes mellitus,<sup>4</sup> though other studies have failed to show an association between cows' milk, cereal, fruit, vegetable, or meat ingestion and  $\beta$  cell autoimmunity.<sup>5</sup> Further research in the form of prospective, controlled studies is needed to confirm any association between insulin dependent diabetes mellitus and diet in infancy. No association between the age of introduction of solids and adult obesity, hypertension, coronary vascular disease, or osteoporosis has been found.<sup>6</sup>

The Barker hypothesis seeks to explain the mechanism whereby early nutritional exposure influences later health by a process of “programming”. The hypothesis holds that as an adaptation to under-nutrition at a critical or sensitive period of development, permanent metabolic and endocrine changes occur which would be beneficial if nutrition remained scarce.<sup>7–8</sup> Low weight at 1 year of age, as well as low birth weight, are associated with an increased risk of cardiovascular disease and non-insulin dependent diabetes mellitus in later life.<sup>9</sup> Furthermore, in a recent paper Barker concluded that irrespective of size at birth, low weight gain during infancy is associated with increased risk of coronary heart disease.<sup>10</sup> The relevance of the Barker hypothesis to current practice in infant nutrition is unclear. Nonetheless, his findings serve to emphasize the increasing recognition of the importance of early life nutrition.

Another important determinant of the appropriate age for weaning is the physiological maturity of gastrointestinal and renal function. There are concerns, firstly, that the high permeability of the young infant's digestive tract may permit

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large foreign proteins to penetrate and provoke immune sensitisation; and secondly, that foods with a high solute load may result in the need to concentrate urine to a degree that exceeds the capacity of the young infant's kidneys. This second concern would of course be especially relevant in the presence of diarrhoea. However, this concern seems unfounded in relation to the early provision of solid food to infants in western industrialised countries because hypernatraemia is rarely seen in the first six months of life since the reduction in the use of cows' milk and high osmolar formulas. A further consideration in determining the optimum age to introduce solids is the interference of non-breast milk foods with the bioavailability of important nutrients found in breast milk, including iron and zinc.

### INTERNATIONAL RECOMMENDATIONS

"Breast is best". This was reconfirmed in a compelling review of the benefits of breast feeding recently published in this journal.<sup>11</sup> We should all promote breast feeding and support the WHO/UNICEF UK "Baby Friendly Hospital Initiative".<sup>12</sup> Eventually, however, the volume of milk required to meet energy and other nutrient needs will exceed the mother's lactational capacity or the baby's ability to consume a sufficient volume of milk. Ideally weaning should occur at a time before this stage is reached.

In May 2001 the World Health Assembly resolved, "to strengthen activities and develop new approaches to protect, promote and support exclusive breast feeding for 6 months as a global public health recommendation".<sup>1</sup>

This resolution was based on a review of current scientific knowledge on complementary feeding in developing countries,<sup>2</sup> and is supported by a separate WHO systematic review of scientific evidence.<sup>13</sup> The systematic review found no apparent risks in recommending, as public health policy, exclusive breast feeding for the first six months of life in both developing and developed country settings. However, the reviewers identified only 16 studies which met their selection criteria, and of these only two were controlled trials which did not receive "high methodologic quality ratings". The remaining 14 were observational studies "of variable quality". Small adverse effects of exclusive breast feeding for the first six months of life could not be ruled out. The reviewers recommended that infants be managed individually so that insufficient growth and other adverse outcomes are not ignored and appropriate interventions provided. In a further systematic review of published research on the age of introduction of complementary foods, Lanigan and colleagues<sup>14</sup> searched over 400 published papers and selected 33 for meta-analysis. This review showed a lack of evidence either to support or refute a change from the then current WHO recommendations to introduce solid foods into the diet at 4–6 months of age. Importantly the authors identified population subgroups that may benefit from the introduction of appropriate complementary foods sooner than the majority of the population. As with the WHO systematic review, all the studies in the Lanigan review had methodological failings.

### SHOULD WEANING OCCUR AT 4 OR 6 MONTHS?

In the UK there is a consensus among scientists and policy makers that weaning should not occur before 4 months of age, but there is debate about the universal application of a policy to delay weaning until 6 months of age. The debate encompasses concerns about growth and nutritional adequacy of exclusive breast milk feeding for *all* infants until 6 months of age versus the risks, especially of infection, associated with earlier weaning.

Concerning growth, the results of two randomised intervention studies from Honduras<sup>15, 16</sup> have reassured policy makers of the safety of prolonged exclusive breast feeding. No significant improvement in growth nor, incidentally, any disadvantage for

morbidity, was seen from a policy of introducing complementary foods at 4 months versus continued exclusive breast feeding to 6 months in these studies. However sample sizes were small and analysis was on the basis of adherence with allocated feeding group rather than intention to treat. Less reassuring are the results of a recently published study from India,<sup>17</sup> which showed that stunted growth was least common among children weaned at 3 months of age and that nearly two thirds of children weaned at 6 months were stunted. In an earlier study undertaken by a WHO working group, data from studying infants from western industrialised countries were pooled and analysed.<sup>18</sup> This study found that those infants exclusively breast fed for 4–6 months showed a deceleration in both weight and length gain relative to the international WHO/NCHS reference. However, this reference is based on a decades old study, which included infants who were primarily bottle fed.<sup>19</sup> Furthermore, continued use of this older reference in the field may lead to the introduction of solid foods sooner than necessary.<sup>20</sup> In the UK new "breast from birth" weight centiles have been constructed based on the weight gain of exclusively breast fed infants. These centiles are a third of a centile band lower than standard centiles.<sup>21</sup> Further studies of the effect of age of weaning on growth using these newer references are needed.

With regard to nutritional adequacy, the relevant question is how long can a mother breast feed exclusively before there is a nutritional need to introduce additional foods? For the majority of healthy full term infants, a sufficient volume of breast milk from a well nourished mother should supply the nutrient needs of the infant until about 6 months of age.<sup>22</sup> The possible exceptions to this are vitamin D,<sup>23</sup> which will constitute a problem if very little sunlight reaches the infant's skin, and zinc where the physiological decline in the zinc content of human milk, which occurs regardless of maternal zinc status, may lead to marginal zinc status in infants from 4–5 months of age onwards.<sup>24</sup> Other micronutrients, which can occasionally be deficient before 6 months of age in some fully breast fed infants, are iron, and vitamins A, B<sub>12</sub>, and riboflavin.<sup>2</sup>

Regarding infection in the context of whether weaning should occur at 4 or 6 months, in economically developing countries it is well documented that diarrhoeal and respiratory illnesses are more common among infants introduced to solids early, than among infants who remain exclusively breast fed.<sup>25, 26</sup> In contrast, rates of infective diarrhoeal illness are low in industrialised nations, despite a high prevalence of early introduction of solids into the diet, and over-hygienic child rearing is being blamed for the rising incidence of allergies.<sup>27</sup> Compared to economically developing countries, there have been few studies examining the short term health effects of early weaning among infants in industrialised countries. The results of a study from Dundee showed no increase in gastrointestinal illness among those weaned before 12 weeks compared to those weaned later, when appropriate adjustments for maternal age and social class were made. However, these infants experienced more respiratory illness at 14–26 weeks.<sup>28</sup> A later examination of the same cohort revealed an increase in wheezing illness, weight, and body fat among 6–10 year old children who had received solids early,<sup>29</sup> though it is not clear whether the early weaning caused the increase in weight and body fat or if bigger babies demand solids sooner. As an aside, this problem of reverse causality is intrinsic to all observational studies, which underpin most of our affirmations on early nutrition. The only evidence in a western industrialised country setting for an advantage of 6 over 4 months exclusive breast feeding comes from a large cluster randomised trial of an experimental intervention based on the baby friendly initiative carried out in Belarus.<sup>30</sup> The intervention increased the duration and degree (exclusivity) of breast feeding and decreased the risk of gastrointestinal tract infection (9.1% versus 13.2%; adjusted OR 0.6; 95% CI 0.40 to 0.91).

Thus, the available evidence supports the safety of exclusive breast feeding for the first six months, though there is an

acknowledged need for further large randomised trials to establish the effects, if any, on growth and morbidity.

### CURRENT UK RECOMMENDATIONS

At the present time in the UK, the Department of Health Recommendations<sup>31</sup> remain, that for the majority of infants, weaning should commence at 4–6 months. However, the new UK Scientific Advisory Committee on Nutrition (SACN) recently endorsed the WHO resolution on exclusive breast feeding for six months. Importantly the committee added: “there should be some flexibility in the advice, but any complementary feeding should not be introduced before the end of 4 months”.

### UK PRACTICE

Despite these recommendations mothers in the UK tend to wean their babies earlier and only a minority breast feed for more than 10 weeks. For example, in 2000 the majority (85%) of UK mothers had introduced solid food by 4 months,<sup>32</sup> and by the time their babies were 4–10 weeks old just a quarter of mothers were feeding their babies entirely with breast milk. Anecdotally, those mothers attending the Winchester paediatric outpatient clinic with their babies and who abandon breast feeding prematurely do so either because of concerns about infant weight gain or because of the need to return to work. Many who continue to breast feed say they would abandon breast feeding completely rather than maintain exclusivity. It is relevant to comment that promoting exclusive breast feeding for six months would be difficult without extending statutory maternity leave!

In the UK in 2000, 30% of mother did not breast feed at all, and by 4–10 weeks, 58% had switched entirely to infant formula milk.<sup>32</sup> The WHO recommendations for weaning take no account of the likely differing nutrient requirements of the exclusively breast fed versus the formula or mixed formula and breast fed infant. The nutrient density of standard cows’ milk formula is greater than that of breast milk. Consequently the formula fed infant is less reliant on initial solid foods for the provision of vitamins and minerals than the breast fed infant. More research is needed in this area,<sup>33</sup> but on present knowledge it could be argued that breast fed infants should receive foods such as meat or iron fortified foods earlier in the weaning process than formula fed infants, in whom cereals would suffice as the initial solid food.

The social and cultural practices prevalent in the UK would not appear to be amenable to a major shift in weaning policy. The interests of infant health may be better served by encouraging more mothers to breast feed, if only for a few weeks, and by discouraging solid feeding before 4 months than by recommending exclusive breast feeding for six months.

### PROVISION OF NUTRIENTS FROM 6–12 MONTHS

In later infancy, once energy needs are supplied by breast milk or formula alone, or in combination with solid foods, iron and zinc are the nutrients most likely to be deficient in infant diets in the UK. Elsewhere, protein, iron, zinc, calcium, iodine, copper, selenium, vitamin A, one of the B vitamins, especially B<sub>12</sub> in vegan mothers, or vitamin D may become the limiting nutrient.<sup>2 22 34</sup> In the UK, a large survey in 1992 found the median iron intake of full term babies 6–12 months of age to be below the reference nutrient intake (RNI), and that the mean zinc intake for this age group was only 90% of the RNI for zinc.<sup>35</sup>

### SPECIAL CASES 1—ATOPIC INFANTS

Evidence that early exposure to food allergens predisposes to the later development of asthma, as opposed to wheezing in early childhood, is lacking.<sup>36</sup> In fact two recent large and well conducted studies in unselected populations have shown

breast feeding to be a risk factor for the development of asthma.<sup>37 38</sup> The pioneering studies of the late David Hide from the Isle of Wight failed to produce significant support for the suggestion that early exposure to food allergens increased the prevalence of allergic sensitisation.<sup>39</sup> More recent studies examining the relation between infant diet and subsequent development of atopic disorders show the greatest effect of diet on short term outcomes among infants at high risk of allergy and little or no effect on long term outcomes in unselected populations. For example, a prospective randomised control study in high risk infants of combined maternal and infant food allergen avoidance showed a reduction in food allergy and milk sensitisation at 2 years follow up, but no difference in any atopic disease or any marker of atopy at age 7 years.<sup>40</sup> By comparison, a systematic review and meta-analysis of studies from the 1966–2000 Medline database concluded that exclusive breast feeding for the first three months of life was associated with a lower incidence atopic dermatitis during childhood in those with a family history of atopy.<sup>41</sup> This is in complete contrast to the findings of an observational study of a large birth cohort from Germany, whose authors concluded that the risk of atopic dermatitis increased with each additional month of breast feeding.<sup>42</sup> A recent unpublished study has found that the introduction of more than four solid foods to preterm infants before 17 weeks post term is associated with a higher risk of eczema at 12 months (J Morgan, personal communication). Current medical opinion recommends that infants at high risk of allergy should be breast fed or given hypoallergenic formula for at least six months and solid foods no sooner than 4–6 months.<sup>6</sup> The lack of any convincing evidence of long term benefit of early allergen avoidance is reason to exercise caution about over-zealous practice, which might compromise an infant nutritionally.

### SPECIAL CASES 2—LOW BIRTH WEIGHT AND PRETERM INFANTS

There is a growing recognition that low birth weight and preterm infants have special nutritional needs in the period post-discharge from the neonatal unit. Additional requirements for energy,<sup>43 44</sup> protein,<sup>45</sup> long chain polyunsaturated fatty acids,<sup>46</sup> iron,<sup>47</sup> calcium,<sup>48</sup> and selenium<sup>49</sup> have all been shown. Medical complications of preterm birth, together with immaturity of digestion, absorption, and metabolism lead to poor intake and assimilation of nutrients in infants while on the neonatal unit. Already limited stores of nutrients are depleted and growth impaired. Thus, many infants leave the neonatal unit with very low nutrient stores and are severely growth retarded. Some preterm and low birth weight infants have ongoing medical problems such as chronic lung disease, which increase nutrient requirements, and some have ongoing medical problems, such as chewing and swallowing difficulties, which decrease nutrient intakes. In one of the only randomised controlled trials of a weaning intervention, preterm infants were offered solid foods of a higher nutrient density than currently recommended from 3 months of postnatal age. The intervention group showed improved linear growth over 18 months and improved haemoglobin and iron status at 6 months post-term.<sup>50</sup> Current recommendations for weaning should take account of the special needs of preterm and low birth weight infants, because their additional nutrient needs might not be adequately met by exclusive breast milk feeding for four months post-term.

### SPECIAL CASES 3—ETHNIC MINORITY POPULATIONS

In the UK the rates of breast feeding in immigrant communities reflect the low rates found in inner city areas rather than the high rates of breast feeding found in the countries of origin.<sup>3 10</sup> The UK infant feeding 2000 survey found that mothers from ethnic minority backgrounds introduced solids later

than white mothers and those of Asian, black, and other ethnicity were more likely than white mothers to have introduced solids after 6 months.<sup>32</sup> In Muslim Asian populations, late weaning, the practice of introducing "doorstep" milk from 5–6 months, and the continued use of convenience baby foods, containing mainly carbohydrates, well into the second year of life may lead to deficiencies of iron and vitamins A, C, and D.<sup>51–52</sup> The earlier introduction of solids and the use of a greater diversity of solid food should be encouraged in these populations. Additional measures such as state benefits, food fortification, and vitamin D supplementation have been suggested.<sup>53</sup> Hindu parents are particularly likely to give vegetarian diets.<sup>31</sup> It is important to ensure that infants on these diets receive adequate energy intakes and that the diet contains high levels of vitamin C to enhance absorption of iron, zinc, and copper, which might otherwise be inhibited by phytates and other inhibitors found in vegetarian diets.<sup>31</sup>

### THE WEANING PROCESS

For the majority of infants weaning should commence between 4 and 6 months of age.<sup>31</sup> Within this age range, gastrointestinal development and renal solute load considerations will not be a major consideration in food choices for healthy infants with the following provisos: salt (sodium chloride) should not be added to any infant foods, nor used in the cooking medium; and all foods should be in a form commensurate with neuromuscular development.<sup>54</sup> While the aetiological origins of food intolerances often remain unclear, it would appear prudent to delay introduction of the foods most commonly associated with atopic disease and enteropathies. The usually accepted list of allergenic and enteropathic foods are gluten containing cereals (wheat, barley, rye, and oats), cows' milk, egg, fish, soybean, and nuts.<sup>31–55</sup> The introduction of new foods in a gradual process, using a few pureed semisolid foods followed by an increasing familiarisation with a greater range of tastes and textures and the beginning of self feeding, should take at least six months. From 1 year of age, a child should be capable of participating in family meals and eating at least some family foods.

The nutritional content of weaning foods becomes of increasing importance as infancy progresses. The most pertinent concerns are the nutrient densities of the foods and the bioavailability of essential micronutrients therein. When compiling weaning guidelines the following recommendations should be particularly considered:

- (1) Energy density should be greater than that of breast milk and ideally around 4.2 kJ/g.<sup>22</sup>
- (2) Meat or iron fortified weaning foods should be introduced early to increase iron intake.<sup>22</sup>
- (3) Meat, pulses, dairy products, wheat, and rice should be included as appropriate to increase zinc intake.<sup>22</sup>
- (4) Phytate levels should be kept relatively low to enhance mineral absorption.<sup>22</sup>
- (5) The change from breast milk/formula to cows' milk should be delayed until after 1 year of age.<sup>31</sup>
- (6) Drinks, other than breast milk, formula, and water, should be discouraged.<sup>31</sup>

Good nutritional practice, incorporating all of the above, would be compatible with guidelines that include the initial use of baby rice mixed with the infant's normal milk, followed by the gradual introduction of vegetables, then fruits, cheese, yoghurt or fromage frais, and lean meat, all in pureed form. At 7–8 months of age, more texture could increasingly be introduced into all foods, together with soft finger foods and wheat and soy products. After 9 months of age, egg and fish could be offered to the child, but nut products would not be included in the diet until beyond 1 year of age. It is essential that accurate information about appropriate weaning foods and practice is

disseminated to prevent infant malnutrition,<sup>56</sup> problems with development, or longer term eating and health problems.

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