Exclusive and Partial Breast-Feeding and Infant Development in Central Africa

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Literature concerning the growth of breast-fed infants is abundant, but still it remains difficult to come to a definite conclusion. Several books and articles have been published about breast-feeding and infant growth (1–7). However, most studies do not consider at the same time all the factors involved in infant growth, and therefore, as a rule, comparisons between different studies are impossible (8). We have tried another approach and built up different, simple models representing the possible interactions affecting the growth and nutritional status of infants (9).

FACTORS AFFECTING GROWTH AND NUTRITIONAL STATUS OF INFANTS

The nutritional status of infants and young children in developing countries depends not only on food intake (from both a qualitative and a quantitative point of view), but also upon infections (mainly gastroenteritis and measles) and parasitoses (especially intestinal parasitoses and malaria) (10–12). The interactions between malnutrition and infection or parasitoses are complex ones in which the immune defense system plays a key role; decreased immune defenses, secondary to malnutrition, will enhance parasitoses and/or infections, but abnormal responses by the immune system, as in some autoimmune and allergic diseases, may also cause malnutrition (13) (Fig. 1). Unlike other foods, breast milk improves the nutritional status of the infant, not only because of its energy and nutrient content but also because it lessens the deleterious effects of infections such as gastroenteritis and measles (14–16). In Kigali (Rwanda), Lepage et al. (17) have observed that the mortality due to measles, gastroenteritis, and acute lower respiratory diseases in children up to 2 years of age is significantly lower when they are breast-fed. Human milk contains antibodies against a variety of germs and their toxins. Some

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of these germs, present in the digestive tract of the infant, may contaminate the mother’s gut, resulting in a local immune response and triggered lymphoid cells homing to the mammary gland (enteromammary immune system) (18,19).

These lymphoid cells secrete specific secretory IgA in the milk. Antibodies (secretory IgA) directed against food components have also been found in milk (18,20,21). Antibodies against food components found in milk depend on the antigenic exposure of the mother; thus the food components need to be present in the mother’s diet. This explains why it is so difficult to introduce cow’s milk as a supplement to a breast-fed baby when the mother does not drink milk.

Figure 2 describes the possible relationships between socioeconomic environment, nutritional status of the mother, sucking behavior, and quantity and quality of the milk produced. These interrelationships were discussed in depth at a workshop held in Cambridge, England (7). The sucking behavior can be influenced by several factors, including the number of close contacts between mother and infant, the night feeds, and the introduction of a food supplement to the infant. The last depends not only on the socioeconomic environment, but also on the mother’s nutritional status. The sucking pattern may influence the length of postpartum amenorrhea, which in turn determines, in some traditional populations, the duration of breast-feeding by controlling the time interval between births, since a new pregnancy signals the end of breast-feeding.

Postpartum insertion of intrauterine devices, progestins (oral or implanted), and low-dose formulations of combined oral contraceptives do not interfere with milk production and infant growth (5).

The nutritional status of the lactating mother is influenced by many factors (Fig. 3) that influence each other by multiple feedback phenomena. It may therefore be erroneous to think that changing one particular factor would only have a single effect. For example, increasing the food intake of the mother will not necessarily improve milk production (22,23). A supplementary energy intake by the mother
FIG. 2. Factors influencing breast milk quantity and quality. (LHRH = luteinizing hormone releasing hormone.)

FIG. 3. Factors influencing the mother's nutritional status.
may be diverted to increase her energy output or to increase her fertility and reduce
the duration of postpartum amenorrhea. It is possible for the mother, by changing
her behavior, to consciously or unconsciously modify energy output, limit the
duration of breast-feeding, etc. This makes comparisons of results of the literature
in this area so difficult (3).

INFANT GROWTH

The growth of an infant is optimal when weight and height are between the 25th
and 75th centiles of the reference curves. For many years, the reference curves
(Stuart-Meredith growth charts) (24) were based on the charts of weight/age and
height/age buildup at the University of Iowa (25) and at Harvard (26). Actually,
the reference charts are those of the National Center of Health Statistics (27,28).
Besides, the growth curves, the psychosomatic evolution, and the maturation of
the different tissues (bones, nervous system) are of great importance. In rural areas
of developing countries, the pattern of infant growth curves is different from that
of reference curves (2,29,30). The birth weight is equal or inferior to 3.0 kg; during
a few weeks following birth the weight curve displays a certain "catch up" and,
under certain conditions, may reach the 50th centile of the reference curve; growth
faltering is then observed between the ages of 3 and 6 months depending upon the
region being investigated. As a consequence, the weight curve of infants in rural
areas of developing countries remains consistently below that of infants in indus-
trialized countries. There is general agreement that the particular pattern of the
growth curve is not related to genetic differences (29). Because these infants are
breast-fed, the faltering of the growth is attributed to insufficient food intake or
increased exposure to infection (4,31). It is very difficult to determine which of
these factors plays the most important role, due to the fact that very few studies
have described the growth curves of well-nourished and exclusively breast-fed
infants whose sucking behavior is comparable to that described in developing coun-
tries and whose mothers have good nutritional status and are not subject to infections
or to seasonal variations in food intake. Wallgren (32) and Ahn and MacLean (33)
demonstrated that motivated mothers were, in some circumstances, able to breast-
feed exclusively for periods of 6 months, their infants’ growth curves being com-
parable to reference curves for weight. Jackson et al. (34) compared the growth in
length and weight through the first 6 months of "well-born," healthy, well-cared-
for American infants fed either human milk or cow’s milk formulas. The growth
pattern in length of breast-fed infants of both sexes, who did not receive supple-
mentary vitamins or solid foods before the age of 6 months, was remarkably similar
to the 1945 Iowa norms; increase in weight was almost identical to the Iowa norms
during the first 3 months for girls and during the first 2 months for boys. Thereafter,
weight gain of breast-fed infants was somewhat less until 6 months; an accelerated
weight gain could be observed at the time additional foods were given, so that the
median weights for boys and girls at 11 months of age were comparable to the
Iowa norms. The same observations were made in breast-fed infants receiving solid
foods from the second and third month on and vitamins from birth. Girls in this
group were slightly taller at birth and remained so throughout the whole period of observation. Both breast-fed and artificially fed boys weighed somewhat less from the second month of life on. In most other studies (35,36), infants were not exclusively breast-fed and the possible influence of early introduction of other foods on milk output was not studied. In conclusion, it appears that fully breast-fed infants may, in some conditions, achieve an optimal growth during the first 6 months of life. Jackson et al. (34) have also emphasized the consistency and predictability of growth in length of normal infants. It is claimed that short stature is a risk factor for later malnutrition (37).

BREAST-MILK PRODUCTION AND GROWTH OF INFANTS IN CENTRAL AFRICA

The population of deprived rural areas in the highlands of Central Africa (Kivu, Zaire) lives in a near-subsistence economy. There are seasonal variations in food intake. The scarcity observed during the period between harvests principally affects the protein intake and, to a much lesser degree, the energy intake (38). The most prevalent type of malnutrition is kwashiorkor rather than marasmus (39). Mainly children present with malnutrition, often a long time after weaning, but also adolescents and adults, mostly lactating and pregnant women. In fact, a large proportion of the population suffers from malnutrition. Birth control is not practiced, and all fertile women are either pregnant or nursing. In addition, the women are responsible for a large part of the field work. Therefore, women of the rural areas are particularly vulnerable to malnutrition. Their bodyweight is below 54 kg. Weight gain during pregnancy is seldom above 5.0 kg; therefore, no extra reserves in the form of fat are available to cover energy needs during the first months of lactation. The quantity of milk produced is thus entirely dependent upon food intake, which varies seasonally. Mean birth weight is below 3.0 kg (2.9 kg for boys and 2.8 kg for girls), serum albumin levels are low.

Characteristic signs of kwashiorkor in nursing mothers are by no means rare. Postpartum amenorrhea is particularly long because of prolonged breast-feeding and chronic malnutrition: only 10 to 15% of the mothers are menstruating 1 year after delivery; 20% of them still do not menstruate 2 years after delivery. Infants are breast-fed for a long time; 99% are still breast-fed at the age of 1 year and 60% at 2 years (9,40). Supplements are introduced in the diet very early (40), probably because of the insufficient quantity of breast milk. Supplements consist of bananas, cassava, or sorghum meal; all are poor sources of protein.

The nutritional status of mothers is better in cities than in rural areas; the average quantity of milk produced is higher, and the postpartum amenorrhea is also of shorter duration (9). Early weaning of infants in urban areas is not related to nutritional factors. The mothers’ behavior pattern is different in the city, where they are not able to carry their infants with them and feed them upon demand, as in rural areas; children are left at home, where another person cares for them. In the city of Bukavu, manufactured infant formulas are not available and thus didn’t
intervene in the acceleration of abandoning the practice of breast-feeding, as they did in other parts of the world.

In order to compare infant growth in these environments, we chose two groups of mothers, one from a rural area and one from a city. There were no statistical differences between the groups regarding the number of sucklings per day and duration of mother–infant skin-to-skin contacts (Table 1) (41). Prolactin levels of mothers during lactation are comparable in both rural and urban areas (Fig. 4). There seem to be no behavioral differences; therefore, the milk output depends only on the nutritional status of the mother. According to their anthropometric characteristics (Fig. 5) and serum albumin levels (Fig. 6), the nutritional status of lactating mothers is much better in the city.

Important differences in milk production exist between rural and urban areas (Fig. 7). The better-nourished mothers, living in the city, tend to produce nearly twice the amount of milk produced by mothers in rural areas. Bukavu has remained quite rural, and the availability of food is still much dependent on the surrounding countryside. Seasonal fluctuations in food intake are present in both urban and rural areas. However, these fluctuations are more important in the rural area, where the period between bean harvests (the “protein gap” period) is characterized by extremely low milk production. To calculate average figures for both environments, we need to take into account, statistically, fluctuations in milk production and composition (Table 2). On the average, protein nitrogen and fat concentrations are lower in the urban area during the whole lactation period and the first 4 months; however, lactose concentration is higher in the city.
FIG. 5. Weight (height)$^2$ of lactating mothers (mean ± SEM).

FIG. 6. Serum albumin levels of lactating mothers (mean ± SEM).
**TABLE 1. Frequency and duration** (mean ± SD) of infant–mother contacts in the rural area and in the city (12-hr observation)

<table>
<thead>
<tr>
<th></th>
<th>City (N=60)(^b)</th>
<th>Rural area (N=60)(^b)</th>
<th>Mann-Whitney U-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suckling duration</td>
<td>71 ± 34</td>
<td>56 ± 40</td>
<td>3.17(^c)</td>
</tr>
<tr>
<td>Suckling frequency</td>
<td>6.4 ± 3.5</td>
<td>5.8 ± 2.5</td>
<td>1.27</td>
</tr>
<tr>
<td>Duration of mother–infant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>skin-to-skin contact</td>
<td>166 ± 119</td>
<td>143 ± 85</td>
<td>1.38</td>
</tr>
<tr>
<td>Frequency of contacts</td>
<td>6.6 ± 3.8</td>
<td>7.4 ± 2.8</td>
<td>0.64</td>
</tr>
<tr>
<td>Duration of infant–other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>children skin-to-skin contacts</td>
<td>239 ± 155</td>
<td>154 ± 92</td>
<td>3.21(^c)</td>
</tr>
<tr>
<td>Frequency of contacts</td>
<td>6.6 ± 3.9</td>
<td>6.4 ± 3.0</td>
<td>0.46</td>
</tr>
<tr>
<td>Overall duration without</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>contacts</td>
<td>249 ± 121</td>
<td>352 ± 124</td>
<td>5.22(^c)</td>
</tr>
<tr>
<td>Overall frequency</td>
<td>6.9 ± 4.1</td>
<td>9.3 ± 3.0</td>
<td>4.73(^c)</td>
</tr>
</tbody>
</table>

From ref. 41, with permission.

\(^a\)In minutes.

\(^b\)N = Number of mother–child pairs.

\(^c\)p = .001.

**FIG. 7.** Milk production (g/24 h) (mean ± SEM).
<table>
<thead>
<tr>
<th>Quarter</th>
<th>Lactose (g)</th>
<th>Lipids (g)</th>
<th>Total nitrogen (mg)</th>
<th>Nonprotein nitrogen (mg)</th>
<th>Energy (kcal)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>6.58</td>
<td>6.11</td>
<td>2.88</td>
<td>4.36</td>
<td>289.6</td>
</tr>
<tr>
<td>2</td>
<td>6.82</td>
<td>6.12</td>
<td>3.22</td>
<td>3.56</td>
<td>244.6</td>
</tr>
<tr>
<td>3</td>
<td>6.74</td>
<td>6.07</td>
<td>3.22</td>
<td>3.73</td>
<td>201.5</td>
</tr>
<tr>
<td>4</td>
<td>6.21</td>
<td>5.85</td>
<td>3.50</td>
<td>3.25</td>
<td>204.4</td>
</tr>
<tr>
<td>X</td>
<td>6.59</td>
<td>6.03</td>
<td>3.20</td>
<td>3.72</td>
<td>210.0</td>
</tr>
</tbody>
</table>

*Energy is calculated as follows: (lactose (g) × 4) + (fat (g) × 9) + (total nitrogen - nonprotein nitrogen) × 6.25 × 4).

Quarter 1 = January–March; quarter 2 = April–June; quarter 3 = July–September; quarter 4 = October–December.
Some data (42) show that the concentration of protein nitrogen is higher in milk from mothers of deprived and well-to-do social classes from developing countries than in the milk from mothers from industrialized countries. The higher nitrogen content is possibly due to increased levels of immunoglobulins and lactoferrin rather than to lactalbumin. The quantities of anti-infectious proteins increase in response to the environment and suggest the importance of the enteromammary immune system, which still has not been demonstrated. Robyn et al. (personal communication, 1982) have shown that in Kivu the lactoferrin and lysozyme content of milk can vary in urban and rural areas and according to the age of the nursing infant (Figs. 8 and 9). This suggests that in a deprived nutritional environment, the quantity rather than the quality of breast milk is affected.

**FIG. 8.** Lactoferrin in breast milk in an urban (Bagira) and rural (Kabare) area. (Robyn et al., personal communication, 1982.)
The growth curves of breast-fed infants in a rural area and in the city are shown on Fig. 10 (weight) and Fig. 11 (height). In the rural area, growth retardation appears on the weight curve around 3 months, whereas 20 years ago in the same population it appeared only between the fourth or fifth month. In the city, faltering of the weight curve occurs between the sixth and seventh month.

The pattern of the height curves is different from that of the weight curves. In the rural area, the height remains well below the reference curve from the time of birth onwards, and in the city from the third month on. Height seems to be a better indicator of deprived environment, even during fetal life.

The first episodes of diarrhea and the first intestinal parasitoses (most ascariasis) are seen much earlier in the rural area than in the city, probably due to the earlier introduction of supplements to breast-fed infants because of low milk production. In these circumstances, measles may also occur before the age of 6 months.

There are also striking differences between the two areas with regard to serum albumin levels, which remain low from birth onward in the rural area (Fig. 12).
CONCLUSIONS

The example of Central Africa, where prolonged breast-feeding is the rule, demonstrates that the development of infants depends both on the mother's behavior and nutritional status and on the possible occurrence of infections and parasitoses in the infant. It also shows that in a very deprived situation, growth of the breast-fed infant is impaired from the beginning: fetal growth is impaired; the quantity of milk produced by the mothers is low; early food supplements are responsible for the early appearance of infections and parasitoses. This situation can only be controlled, and to a certain extent, by the anti-infectious properties of breast milk. Protein malnutrition seems to be as important as energy deprivation. Mothers are not accustomed to eating foods rich in protein of good quality (e.g., cow's milk), and it is therefore difficult to introduce these as supplements into the infants' diet. The contributions of infections, parasitoses, and inadequate food intake on the growth faltering of nursing infants are still not well defined (43). In those circumstances, one should promote exclusive breast-feeding of long duration (5–6 months), which is not easily achieved.

FIG. 10. Weight-growth curves of breast-fed boys and girls of the city of Bukavu and a rural area. Comparison with the reference growth curves of the National Center for Health Statistics (27) and the 1959 growth curve for boys of the same rural area. From 3 to 4 weeks on, most infants receive a supplement. The faltering of the curve occurs in the city around 6 months of age and before 3 months in the rural area. Around 1 year of age there seems to be no difference between the two weight curves of rural area. This is perhaps due to the higher infant mortality in 1979 than in 1959, due to the worsening of the nutritional situation.
FIG. 11. Height curves of infants from the city and the rural area.

FIG. 12. Serum albumin levels of infants from the urban area (Bukavu) and the rural area (mean ± SEM).
REFERENCES


APPENDIX: PROPOSED GLOSSARY

Breast feeding. Feeding from the breast of the mother or of another woman.

Complete breast feeding. Feeding from the breast exclusively, apart from water or fruit juice in very small quantities, or of vitamin concentrates. (Synonyms: totally, fully, or solely breast fed.)

Partial breast feeding. Breast feeding associated with other food provided in significant amounts and on a regular daily basis.

Mainly breast fed. Breast milk provides most of the energy in the total diet.

Nibbling. The child sucks at the breast for comfort and emotional relief but does not obtain significant amounts of milk.

Weaning from breast. The process of withdrawing breast feeding, which may be gradual or abrupt.

Partial weaning from breast. The process of weaning has not been completed.

Complete weaning from breast. Breast feeding has stopped completely.

Artificial feeding. (Often referred to as bottle feeding.) Feeding with a substitute for breast milk.

Complete artificial feeding. The breast milk substitute forms the sole diet. (Synonym: total artificial feeding, also often referred to as completely bottle fed.)
Mainly artificially fed. A breast milk substitute provides most of the energy in the child's diet. Complementary feeding. Breast feeding plus a breast milk substitute ("complement"). (N.B. In French, "alimentation supplémentaire.")

Mixed feeding. In addition to breast milk, infants receive additional solid foods or paps ("supplements") in significant amounts on a regular daily basis. (Synonym: supplementary feeding. N.B. In French, "alimentation complémentaire.")

DISCUSSION

Dr. Shanti Ghosh: We know that well-nourished women, when they make up their minds to feed their babies, can feed fairly successfully. However, I should like to make one comment: It is very difficult to test the efficacy of maternal nutritional supplements because, according to my experience, most of the time the mother does not eat the supplement that is given to her, but she uses it for the family and very often feeds her children with it.

Dr. Ferguson: It was very clear from the presentation that many methods of intervention have already been tried, such as supplementing the mother's food, different weaning times, and so on. None of these work and it was quite clear from your final diagram that this is due to the pattern of life in these societies. You did not mention the role of the father. Surely it is worth stating that a possible mode of intervention would be social pressure on the men of the village to try and reduce the amount of work expected of the women. Has this ever been tried by psychologists or sociologists in any developing country?

Dr. Vis: The key issue in an area such as Kivu is the birth spacing, in which of course the father is involved. Until now, in these countries, all birth spacing programs (I do not speak of birth limitation) failed for different reasons. It is very difficult to change habits or sociocultural patterns. But apart from that, when socioeconomic conditions improve, birth interval is shortened. That was shown very clearly by the Gambian group. But when the birth interval is shortened in a rural area with a population density of up to 200 inhabitants per square kilometer, infant mortality increases.

Dr. Ferguson: I agree, but all the other methods of intervention have failed. An experiment could be carried out to prove or disprove your hypothesis that rural women have a poor milk output because of the hard physical labor which is expected of them. I believe this would be a most worthwhile experiment to conduct, investigating the relationship between work expenditure and lactation performance.

Dr. Poskitt: I agree with Dr. Ferguson that the solutions include getting the men to do a lot of work, which certainly doesn't occur in many African countries. It seems to me that the answer to a lot of these problems lies in political solutions rather than in medical ones, in that if you could improve hygiene, put in some sewers, and remove poverty, you would see a great difference. I wonder, Professor Vis, whether you saw seasonal variations, because certainly in Uganda we saw tremendous variations depending on the time of year. At the beginning of the rainy season the children would get measles, respiratory tract infections, gastroenteritis or marasmic kwashiorkor, and the weight curves plunged. The fact that at that time the women went into the fields to do their digging probably contributed to this and I suppose if you compared the growth curves of children born during the rainy season as opposed to 6 months later, it might give you some idea of the part played by infection in their growth pattern.

Dr. Vis: I agree that we are dealing more with a political problem than with a medical one. There are seasonal variations in milk output, of course, because the milk output depends
on the labor of the mother and on her food intake; when the food intake drops, the milk output also drops. There are also seasonal variations in albumin levels. An alarming sign is the disappearance of seasonal difference, indicating that albumin levels do not rise anymore, even during the bean harvest.

Dr. Ashfaq Ahmad: I agree with Professor Vis that probably hard work does affect the milk output. This is also demonstrated by our unpublished study showing that the morning milk output, after a good night’s rest, is much higher than in the afternoon when the mother has done the housework. However, I am not convinced that the involvement of the father in these chores would be of great benefit to the mother in our communities. Our experience in involving the father in birth spacing programs and family planning has clearly been very successful. I have a question on the incidence of kwashiorkor: In the East we do not see kwashiorkor all that frequently; the incidence of marasmus is much higher. Could that be due to dietary habits, not only protein intake but contamination of the diet with aflatoxin? Could it play a role?

Dr. Shanti Ghosh: We do not see much kwashiorkor. That is because our basic diet, which is cereal and legume based, is very high in protein. As long as adequate amounts are consumed to satisfy energy needs, the protein is more than enough. Problems appear when the energy need is not satisfied and some of the protein is then utilized for energy rather than for protein. We only see kwashiorkor, what we call marasmic kwashiorkor, when there is a superimposed infection as well, which causes an imbalance.

Dr. Vis: Kwashiorkor is very typical from a clinical point of view, but I think that we should always define protein energy malnutrition when we encounter it. In my opinion what is more important to know is (a) the number of children with kwashiorkor or marasmic kwashiorkor and (b) the incidence of a serum albumin level below 2.7 g/dl.

Dr. Shanti Ghosh: Life in developing countries is very much harder for poor women than it is for poor men, and nobody really knows how to relieve the situation. Men also work very hard, but at the end of a day’s work they sit and relax, have a drink or chat, while the women return to their housework. But apart from this, another thing, at least in our country, is the unfair intrafamily distribution of food. The mother is the last to eat, and by the time her turn comes, very little is left; she gets the smallest portion and certainly she doesn’t get any protective elements at all, she hardly eats any vegetables or meat because all that is given to the children and the “bread winner,” the father. So, not only is she working very hard, but she eats less than the rest of the family. Deep sociocultural and behavioral changes in the whole community are needed to alter this situation. However, wherever women’s literacy has increased, so have their demands on society and their status, and gradually the situation has started to improve. This is the case in all developing countries, at least in southeast Asia, and I am personally very much in favor of increasing women’s literacy to induce social changes and increase the mother’s social status.