Factors Associated with Stunting in Infants Aged 5–11 Months in the Dodota-Sire District, Rural Ethiopia

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Factors Associated with Stunting in Infants Aged 5–11 Months in the Dodota-Sire District, Rural Ethiopia[1]

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ABSTRACT The contribution of various factors to malnutrition, particularly stunting, may differ among areas and communities. This cross-sectional study aimed to estimate the level of malnutrition and identify factors associated with the high level of stunting in breast-fed infants aged 5–11 mo living in Dodota-Sire District, Ethiopia. Infants (n = 305) and their mothers were examined physically, and anthropometric and demographic data were collected. The content of zinc, calcium and copper in breast milk was measured, and data collected on the type, frequency of consumption, and time of introduction of supplementary feeding. Overall, 36% were stunted, 41% underweight and 13% wasted. The highest prevalence of malnutrition was seen in infants aged 9–11 mo. Among mothers, 27% had chronic energy deficiency (body mass index, <18.5 kg/m^2) and 20% were night blind, indicating that vitamin A deficiency was a serious problem. Infants fed >3 times/d, consuming >600 mL/d or consuming cow's milk in addition to cereals and/or legumes had markedly higher length-for-age Z-scores than their peers fed less frequently, consuming less food or not consuming cow's milk [differences: 0.39, 95% confidence interval (CI): 0.04–0.74; 0.17, 95% CI: 0.02–0.32; 0.40, 95% CI: 0.07–0.72, respectively). Infants of mothers with low concentrations of zinc in their breast milk were more stunted. In conclusion, the quality and quantity of foods consumed by infants is insufficient to prevent stunting. Thus it is necessary to increase the nutrient supply to infants by increasing intake and nutrient concentration of breast milk and of supplementary foods they consume, and by providing supplements to infants where appropriate. J. Nutr. 133: 1064–1069, 2003.

KEY WORDS: • *anthropometry* • *breast-feeding* • *nutritional status* • *supplementary feeding* • *Ethiopia*

Malnutrition remains one of the major public health problems in less developed countries, affecting infants and children and women of reproductive age (1). Malnutrition involves deficiencies not only of macronutrients but also of micronutrients. In less developed countries, it has been estimated that ~12 million children <5 y old die annually due to infection and malnutrition, with malnutrition contributing to half of the mortality. Stunting or linear growth retardation is a common result of malnutrition among young children in poor countries (2). Ethiopia is no exception, i.e., nutritional deficiencies and infectious disease are the leading health problems in the country (3–6). At the national level, 64% of the Ethiopian children <5 y old are moderately or severely stunted, whereas 47% are underweight and 8% are wasted (7). These prevalences are among the highest in the world. More surprisingly, a very high prevalence of stunting (75%) was observed in food surplus regions of the country such as West Gojam. Moreover, ~17% of children are estimated to have a low birth weight (< 2500 g) (8).

In developing countries, growth faltering begins within a few months after birth. The causes of early stunting are not yet well understood (9) but may include both a nutritionally inadequate dietary intake and infections (10–12), both of which have their roots in poverty. During the last decade, however, several randomized controlled trials have provided evidence that zinc deficiency, which can be reversed by zinc supplementation, contributes to stunting in children in both developing (13–15) and developed (16–18) countries.

The risk of stunting is greatest during the period of rapid body growth and development, and slows down at ~3 y of age (19). Early stunting is likely to persist through adolescence if children remain in the same environment. Traditionally, malnutrition has been considered to be due solely to a shortage of food in the community, resulting from low economic development, skewed distribution of wealth, poverty, seasonal factors and war. Other factors, such as large family size, poor feeding practices and a high prevalence of infectious disease also play a role. Knowledge of the relative contribution of the major risk factors associated with stunting is therefore an important prerequisite for developing nutrition intervention strategies. We have undertaken a cross-sectional study to examine factors possibly associated with stunting in breast-fed infants in Dodota-Sire District, rural Ethiopia. Infants

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enrolled in this study were subsequently supplemented with zinc, which resulted in a beneficial effect on linear growth and morbidity (20).

SUBJECTS AND METHODS

Study area and population. The study was carried out in July 1996 during the rainy season in a rural area of Dodota-Sire District, Arsi Zone, rural Ethiopia, which is located about 150 km east of the capital, Addis Ababa. In this district, two villages, Dheera and Hamude, were arbitrarily selected. They are located ~40 km apart and both have health facilities and access to all-weather roads. The area lies in the Great Rift Valley of Africa with hot weather and a short rainy season of <2 mo (July and August). During this period, there was an acute shortage of food in the community. The local staple crops are wheat, maize, sorghum, barley and tef, which are grown for subsistence. Diets based on these cereals contain high levels of phytate, which inhibits the absorption of iron and zinc. Traditional rearing of animals, mainly cattle and goats, is commonly practiced as a means of generating cash income. Some milk is consumed, but only after the removal of the cream, which is sold. Vegetables are rarely consumed.

A total of 18 farmers' associations with a population of 22,100 inhabitants within 15 km of the villages were included in the study. A census of all breast-fed infants aged 5–11 mo was made, and their parents were invited to bring their children for the study. All children invited participated in the study. Demographic information was gathered using a pretested questionnaire. Dates of birth of the children were established by a local events calendar with information on anniversaries, festivals, fasting periods and farming seasons. No clinic cards were available from which dates of birth could be established. All infants were born at home with or without assistance of traditional birth attendants, which is the usual practice in rural Ethiopia.

Anthropometry. Length of the infants was measured in a recumbent position to the nearest 0.1 cm using a board with an upright wooden base and a movable headpiece, designed by the Division of Human Nutrition and Epidemiology, Wageningen University. Height of the mothers was measured with the body stretched upward to full extent and including the head, the Frankfurt position without shoes using a wall-mounted stadiometer to the nearest 0.1 cm. Weight of the lightly clothed infants was measured to the nearest 10 g by a metal beam seat balance (Seca, model 725/424, Lameris, Utrecht, Netherlands). Weight of the mothers in light clothes and without shoes was measured to the nearest 100 g by an electronic scale (Tefal, model SC 3218, Rumilly, France). The scales were calibrated each morning and checked at regular intervals throughout the day. Knee-heel length of the infants was measured to the nearest 0.1 mm using an electronic kneemometer (model BK5; Force Institutterme, Brondby, Denmark). Mid-upper arm circumference (MUAC)[3] of both infants and mothers was measured without compression to the nearest 0.1 cm with a flexible nonstretch measuring tape on the left arm with the arm hanging relaxed. Triceps skinfold thickness was measured at the same site to the nearest 0.1 mm by a Harpenden caliper (John Bull, British Indicators, West Sussex, UK). The standardization procedures used to increase accuracy for anthropometric measurements are discussed in detail elsewhere (20). Bioelectrical impedance in children was measured at 100 kHz using a multifrequency impedance analyzer (Dietosystem, Milan, Italy). The injection electrodes were connected to the foot and hand just proximal to the digits, and the sensor electrodes were connected 5 cm proximal to the injection electrodes. The impedance index (length squared/impedance) was calculated as a crude indicator of fat-free body mass.

Clinical examination. Clinical examinations of both infants and their mothers were carried out by a physician. Information was obtained from each mother with respect to the previous 2 wk about her appetite and about the amount and frequency of consumption of supplementary foods by the infant.

Breast milk collection and analysis. Breast milk (~15 mL), obtained from the right breast ~60 min after the last feeding from that breast, was collected in an acid-washed plastic bottle and kept at −20°C until analysis. Concentrations of zinc, calcium and copper in breast milk were determined by atomic absorption spectrophotometry (Varian Spectra AA 10/20 Plus, Varian Techtrone, Mulgrave, Australia) after centrifugation (at 1500 × *g* for 30 min) to remove fat (21).

Stool collection and examination. Each mother was given a cup with a cover in which she collected a sample of her child's stool. The samples were suspended in saline solution immediately upon receipt by the study team in the field and examined by microscopy for the presence of intestinal parasites, particularly *Ascaris*, ameba, hookworm, *Giardia* and strongyloids.

Ethical approval. The study design was explained to officials of the Zonal Health Department of Arsi, administrative officials of Dodota-Sire District, community and religious leaders, and peasant association leaders. The nature of the study was also fully explained to mothers and oral consent was obtained. Permission for the study was obtained from the medical ethical committee of the Ethiopian Health and Nutrition Research Institute.

Statistical analysis. Anthropometric indices were calculated using CASP software (version 3, 1987, Centers for Disease Control and Prevention, Atlanta, GA). Being stunted, underweight and wasted were defined by Z-scores for length-for-age (LAZ), weight-for-age (WAZ) and weight-for-length (WLZ) less than –2 SD below median values of a reference population of U.S. children (22). All other analyses were carried out using SPSS software (SPSS, version 8.0, Chicago, IL). Komolgorov-Smirnov tests were used to determine whether outcome variables were normally distributed. If data were not normally distributed, the Mann-Whitney test was used to assess group differences. Group means were compared by independent *t* tests. Linear regression analysis was used to examine independent associations between supplementary food feeding variables and stunting as assessed by LAZ.

RESULTS

The study included 305 breast-fed infants aged 5–11 mo of whom 146 (47%) were boys and 159 (52%) were girls. Of the infants, 110 (36%) were stunted. Stunted and nonstunted infants differed with respect to most of the parameters examined, with boys more likely to be stunted than girls (**Table 1**). Stunted infants were not only shorter but also weighed less, were thinner as measured by triceps skinfold and MUAC and had a lower fat-free body mass as measured by the impedance index.

Most mothers (>80%) had >4 children, were married (97%), were illiterate (91%), had farming as the major source of income (93%) and were vaccinated against tetanus during pregnancy (72%). Untrained traditional birth attendants attended most deliveries and ~38% of the mothers reported being examined by a nurse after the baby was delivered. Of the mothers, 82 (27%) had chronic energy deficiency (body mass index <18.5 kg/m^2), and mothers of stunted infants were slightly shorter (~2 cm) and had a slightly lower triceps skinfold thickness (**Table 2**). Of the stunted children, 66% were born within 2 y of their older siblings, compared with 52% for the nonstunted children (P = 0.04). More mothers (12%) of stunted infants reported poor appetite compared with mothers of nonstunted infants (7%) (P = 0.06). Signs and symptoms of vitamin A deficiency such as night blindness, Bitot's spots and corneal xerosis in at least one eye were recorded by 20, 1 and 1.5%, respectively, of the mothers. The results did not differ for mothers of stunted and nonstunted children. Breast milk was collected from 253 of 305 mothers (83%); 37 refused to give milk due to ritual beliefs and 15 mothers did not produce enough milk. The concentration of zinc in breast milk of mothers of stunted infants was less than

[3] Abbreviations used: LAZ, length-for-age Z-score; MUAC, mid-upper arm circumference; WAZ, weight-for-age Z-score; WLZ, weight-for-length Z-score.

TABLE 1

Comparison of anthropometric indices in stunted and nonstunted breast-fed infants [1]

Characteristic	Stunted	Nonstunted	Difference Estimate	Difference 95% CI	*P*-value
n	110	195			
Sex, boys/girls	58/52	88/107			
Age,[2] *mo*	9.1 ± 0.2	8.6 ± 0.2	0.5	(0.0, 0.9)	0.07
Length, *cm*	63.7 ± 0.3	68.2 ± 0.3	−4.6	(−5.5, −3.8)	0.001
Weight, *kg*	6.1 ± 0.1	7.3 ± 0.7	−1.2	(−1.4, −0.9)	0.001
Mid-upper arm circumference, *cm*	13.2 ± 1.1	14.1 ± 1.0	−0.9	(−1.6, −0.6)	0.001
Triceps skinfold thickness, *mm*	5.8 ± 0.1	6.6 ± 0.1	−0.8	(−1.1, −0.5)	0.001
Knee-heel length, *mm*	163 ± 11	176 ± 13	−12	(−15.5, −9.4)	0.001
Weight-for-age Z-score (WAZ)	−2.79 ± 0.09	−1.33 ± 0.11	−1.47	(−1.72, −1.31)	0.001
Weight-for-length Z-score (WLZ)	−0.84 ± 0.11	−0.87 ± 0.11	0.03	(−0.22, 0.32)	0.84
Length-for-age Z-score (LAZ)	−2.84 ± 0.06	−0.81 ± 0.07	−2.00	(−2.21, −1.84)	0.001
Impedance index at 100 kHz, *cm*^{2}/Ω	5.6 ± 0.1	6.5 ± 0.1	−0.9	(−1.1, −0.7)	0.001

[1] Data are age adjusted and expressed as means ± SEM. CI, confidence interval. Stunting and nonstunting were defined as LAZ less than −2 SD and greater than or equal to −2 SD, respectively, of the median of NCHS reference population (22).
[2] Marginal difference between groups, $P < 0.07$, Mann-Whitney U test.

that in milk of mothers of nonstunted infants (−1.1 μmol/L, $P = 0.02$). The same appeared to be true for breast milk calcium concentrations (−1.3 mmol/L; $P = 0.08$). There were no differences between the groups in copper concentrations of breast milk.

The overall prevalence of being stunted, underweight, wasted or MUAC <12.5 cm were 36, 41, 13 and 10%, respectively (**Table 3**). Furthermore, the proportion of stunting, underweight and wasting increased with age, with the highest proportion in the 9- to 11-mo-old group. The prevalence of wasting was 15% ($n = 16$) for stunted infants and 12% ($n = 23$) for nonstunted children.

The most common health problems in infants reported in the 2 wk before the interview were cough (10.8%), fever (7.5%), eye diseases (6.9%), scabies (5.9%) and diarrhea (4.3%). There were no differences between stunted and nonstunted infants. The results of the stool examinations for helminths were negative for 97% of the infants. Only strongyloids (1.3%) and *Ascaris* (1.0%) were seen.

The frequency, quantity and type of supplementary feeding were strongly associated with stunting, whereas the age of introduction of supplementary foods was not (**Table 4**). Infants consumed the following types of supplements: cow's milk ($n = 93$, 30.5%), cereals alone (61, 20.0%), legumes only (2, 0.7%), vegetables (1, 0.3%), cereals with legume mix (104, 34.1%) and cereals with cow's milk (44, 14.4%). Of the mothers who claimed to give their infants cow's milk as supplementary food, further questioning showed that they fed their infants cow's milk not >2 d/wk because they preferred to sell it as a means of generating cash. Children given cow's milk tended ($P = 0.05$) to be less stunted. The most common supplementary foods used in the household in this village were *attmit* (thin gruel), porridge and partially or fully fermented

TABLE 2

Comparison of indices of nutritional status of mothers of stunted and nonstunted infants[1]

Characteristic	Mothers of stunted infants	Mothers of nonstunted infants	Difference Estimate	Difference 95% CI	*P*-value
n	110	195			
Age, *y*	26.6 ± 0.6	26.4 ± 0.4	0.3	(−1.1, 1.6)	0.70
Height, *cm*	153.3 ± 0.6	155.1 ± 0.4	−1.8	(−3.1, −0.5)	0.008
Weight, *kg*	47.3 ± 0.6	47.9 ± 0.4	−0.7	(−2.1, 0.7)	0.34
Mid-upper arm circumference, *cm*	22.9 ± 0.2	22.8 ± 0.1	0.1	(−0.3, 0.6)	0.52
Triceps skinfold thickness, *mm*	6.9 ± 0.1	7.7 ± 0.2	−0.8	(−1.3, −0.4)	0.001
Body mass index, *kg/m*^{2}	20.1 ± 0.2	19.9 ± 0.1	0.2	(0.3, 0.70)	0.51
Concentration in breast milk[2]					
Zinc, *μmol/L*	9.2 ± 0.4	10.4 ± 0.3	−1.1	(−2.1, −0.1)	0.02
Copper, *μmol/L*	2.3 ± 0.1	2.2 ± 0.1	0.1	(−0.3, 0.4)	0.74
Calcium, *mmol/L*	0.32 ± 0.02	0.35 ± 0.01	−1.3	(−2.7, −0.2)	0.08
Night blindness,[3] %	23.6	18.6	5.1		0.30
Bitot's spot,[3] %	0.9	1.0	−0.1		1.00
Corneal xerosis,[3] %	1.8	1.0	0.8		0.62

[1] Data are age adjusted and expressed as means ± SEM. CI, confidence interval.
[2] The number of mothers of stunted and nonstunted infants from whom breast milk samples were obtained and analyzed was 92 and 161 respectively.
[3] By Fisher's Exact test.

TABLE 3

Prevalence of indicators of malnutrition in infants per age group[1]

Age	Total number of children	Stunted	Underweight	Wasted	MUAC <12.5 cm
mo	*n*	*n (%)*			
5.0–7.0	85	27 (32)	23 (27)	1 (1)	5 (6)
7.1–9.0	108	37 (34)	27 (25)	8 (7)	7 (7)
9.1–11.0	112	46 (41)	76 (68)	30 (27)	17 (15)
Total	305	110 (36)	126 (41)	39 (13)	29 (10)

[1] Being stunted, underweight or wasted was defined by Z-scores for length-for-age, weight-for-age and weight-for-length respectively, below −2 SD (22). MUAC, mid-upper arm circumference.

enjera (a pancake-like thin leavened bread) or bread prepared from cereals.

DISCUSSION

Our results demonstrate that the quantity and types of food given to the infants and the frequency of feeding are important factors related to stunting in the infants studied (Table 4). Children who were reported to consume relatively large quantities of food (>600 mL/d) had higher LAZ than their peers consuming less food (<600 mL/d). Age of introduction of supplementary foods was less related to stunting. Furthermore, poor appetite and nutritional status of mothers, and low zinc and calcium concentration of breast milk also contributed to stunting of infants.

LAZ is considered to be a good indicator of the nutritional status and health of infants and young children (23). Stunting indicates low growth and is the cumulative effect of low or inadequate intake of energy, macronutrients or micronutrients over a long period or results from chronic or frequent infection. The underlying malnutrition may also contribute to morbidity and mortality from common infectious diseases such as acute respiratory infections, diarrhea, measles and malaria. The high prevalence of stunting found among infants in this study indicates that malnutrition is widespread among children in the study area. Our prevalence estimate (36%) is relatively low compared with national data for the same age range (57%) (7). Communities may vary regarding the factors studied. Because we collected data in only two villages, our descriptive data may not be representative of the country as a whole. This is less relevant with respect to the relationships observed among variables.

The prevalence of wasting (13%) is alarming and very high compared with estimates for Eastern Africa, 7% (24), and the national figure for Ethiopia, 8% (7). Wasting reflects a problem of current or recent starvation, insufficient or inappropriate supplementary foods, or it may be a consequence of acute infectious disease. The survey was undertaken in the wet season before harvesting of crops when most families experienced acute shortages of food. Surveillance of nutritional status and measures to prevent or tackle acute malnutrition should be implemented in this area.

Although stunted infants were thinner (both MUAC and triceps skinfold thickness were lower) than nonstunted infants, such a difference was not reflected in the proportion of wasted children among stunted and nonstunted infants. Of the 110 stunted infants, 16 (15%) were wasted, whereas of the 195 nonstunted infants, 23 (12%) were wasted. Stunted infants also had a lower impedance index than nonstunted infants. Unfortunately, no formula is available for predicting fat-free mass from impedance data in infants. Thus, the impedance index can be used only as a crude indicator of fat-free mass. The fact that the index is lower in the stunted children and correlates well with LAZ ($y = 0.73x - 6.05$; $R^2 = 0.34$) indicates that the stunted children not only are smaller, but that they also have less adipose tissue. However it should be noted that the etiology of wasting is different than that of stunting, as is evident from the fact that stunting usually starts earlier in life (25). Helminths are unlikely to contribute to infant malnutrition in this population because very few of the infants had evidence of helminths in their stools.

Breast milk is an important source of both zinc and vitamin A for the infants during infancy. Zinc from breast milk is well absorbed but becomes inadequate for growth after 6 mo of lactation. Both the concentration and bioavailability of zinc in the supplementary foods given to the infants in this study were low and likely to be less absorbed because of the inhibitory effect of phytate. Thus zinc is insufficient in meeting the infant requirement for growth. The concentration of zinc in breast milk is not affected by the nutritional status of the mother but by age of lactation; thus it is unlikely to increase breast milk zinc concentration. Randomized, controlled trials in lactating mothers did not show any effect of zinc supplementation on breast milk zinc concentration (26,27). In a nonrandomized study, it was found that zinc intake in relatively well-nourished mothers was associated with breast milk zinc concentrations (28). Thus randomized controlled trials should be undertaken in developing countries to determine whether increased maternal zinc intake can enhance zinc concentration in breast milk in such countries. The low concentration of zinc in both breast milk and the diet thus may have contributed to the poor infant growth in stunted infants. We and others have shown that supplementing stunted infants with zinc stimulates

TABLE 4

Independent associations of supplementary food feeding variables with length-for-age of infants as analyzed by multivariate analysis

Effects adjusted for age	*n/n*[1]	Difference in LAZ	95% CI	*P*-value
Frequency of feeding >3 times/d compared with <3 times/d	194/111	0.39	(0.04, 0.74)	0.03
Consuming >600 mL/d compared with consuming <600 mL/d	167/138	0.17	(0.02, 0.32)	0.02
Consumption of cereals and legumes without cows milk	179/126	0.40	(0.07, 0.72)	0.02
Age of introduction of supplementary foods >6 mo compared with <6 mo	213/93	−0.13	(−0.45, 0.19)	0.43

[1] Number of infants in first category/number infants in second category. All but one infant were fed with cereals, legumes or cows milk. CI, confidence interval; LAZ, length-for-age Z-score.

growth (20,29). A recent study showed that deficiencies of vitamin A and zinc occur together in lactating mothers and their infants and that the retinol concentration of breast milk is related to the vitamin A status of infants (30). Randomized controlled trials have shown that supplementation with β-carotene or retinol can lead to increased retinol concentrations in breast milk (31,32). Thus maternal vitamin A status affects the breast milk vitamin A concentration. In this study, 23.6% of mothers of stunted infants had night blindness, a sign of vitamin A deficiency, and their infants are likely at risk of vitamin A deficiency. These findings suggested that the poor micronutrient status of mothers is likely to increase the risk in their infants of deficiencies of zinc and of vitamin A, and poor growth. Adequate maternal vitamin A status and dietary intakes are important to improve the vitamin A transfer to their young infants. Therefore, soon after the survey, we distributed vitamin A capsule to both the mothers and infants in our study.

Stunting in infants may also be caused by low energy intake. In the present study, the energy and nutrient densities of the supplementary foods were low because the foods were prepared from a limited number of local staple cereals and legumes without the addition of sugar or fat. They were also diluted with water to reduce the viscosity to make them more acceptable to the infants. In addition, only 30% of infants were supplemented with cow's milk. Because of the their small stomachs, infants can consume only one-half or one cup of supplementary food per feed, which makes it difficult for them to satisfy their energy and nutrient requirements. This is in agreement with other studies in developing countries (33,34). On the basis of data collected from mothers on the food intake of their infants, we also found that infants fed <3 medium-sized cups (< about 200 mL) per day had lower LAZ scores ($P = 0.03$). Therefore, the small amounts consumed and low feeding frequency are probably important determinants of stunting. No data were collected on consumption of foods from various food groups.

We found that infants born <24 mo after the birth of the previous sibling were more likely to be stunted than those born >24 mo afterwards (data not shown). The resulting poor nutritional status of their mothers, coupled with the increased burden of child care, may result in reduced nutritional status of the infants including stunting. Greater spacing of children would enable mothers to provide better nutrition, care and attention to their children. The consequences of poor nutrition of a mother and her fetus extend far into later life of the child and possibly into the next generation. There is mounting evidence for Barker's fetal origins hypothesis (35) in which it is proposed that undernutrition of the fetus during critical periods of development increases the risk in later life of so-called diseases of affluence such as coronary heart disease. Thus it would be interesting to follow up the children in this study into later life.

The prevalence of night blindness (~20%, Table 2) exceeded 5%, which defines vitamin A deficiency as a public health problem in pregnant women (36). Because most of the women were not pregnant, this proportion is extremely high. We did not observe any evidence of xerophthalmia in the infants; this is not surprising, however, because vitamin A deficiency usually becomes manifest in y 2 of life (37). However, there is growing awareness that subclinical and even clinical vitamin A deficiency is common among infants (38). Vitamin A deficiency has been reported in preschool children living in the same area (39,40). The main staple foods comprise cereals supplemented with legumes, whereas dark-green leafy vegetables are available only during the rainy season. Such foods are known to be poor sources of vitamin A (41).

In conclusion, this study clearly shows that the quality and quantity of foods consumed by infants is insufficient to prevent stunting. Thus, it is necessary to increase the nutrient supply to infants by increasing the intake and nutrient concentration of breast milk and of supplementary foods they consume and by providing supplements to infants where appropriate.

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