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Dietary practices and nutritional status of 0–24-month-old children from Brazilian Amazonia

TG Castro[1,2], LG Baraldi[1], PT Muniz[3] and MA Cardoso[1,*]
[1]Department of Nutrition, School of Public Health, University of São Paulo, Av. Dr Arnaldo 715, São Paulo, SP 01246-904, Brazil: [2]Department of Social Medicine, School of Medicine, Federal University of Rio Grande do Sul, Porto Alegre, Brazil: [3]Department of Health Sciences, Federal University of Acre, Rio Branco, Brazil

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Abstract

Objective: To assess the nutritional status and dietary practices of 0–24-month-old children living in Brazilian Amazonia.
Design: Cross-sectional study. Information on children's dietary intakes was obtained from diet history data. Weight and length were measured for anthropometric evaluation. Fe status was assessed using fasting venous blood samples; Hb, serum ferritin and soluble transferrin receptor concentrations were measured.
Setting: The towns of Assis Brasil and Acrelândia in the state of Acre, north-west Brazil.
Subjects: A total of sixty-nine randomly selected 0–24-month-old children.
Results: Of these children, 40·3 % were anaemic, 63·1 % were Fe-deficient, 28·1 % had Fe-deficiency anaemia and 11·6 % were stunted. Breast-feeding was initiated by 97·1 % of mothers, followed by early feeding with complementary foods. The dietary pattern reflected a high intake of carbohydrate-rich foods and cow's milk, with irregular intakes of fruit, vegetables and meat. All infants and 92·3 % of toddlers were at risk of inadequate Fe intakes. Fe from animal foods contributed on average 0·5 % and 14·3 % to total dietary Fe intake among infants and toddlers, respectively.
Conclusions: Poor nutritional status and inadequate feeding practices in this study population reinforce the importance of exclusive breast-feeding during the first 6 months of life. Greater emphasis is required to improve the bioavailability of dietary Fe during complementary feeding practices.

Keywords
Dietary practices
Complementary feeding
Iron-deficiency anaemia
Breast-feeding practices
Brazilian Amazonia

At about 6 months of age, the supply of energy and some nutrients from breast milk can no longer meet infants' needs, requiring the administration of complementary foods to achieve a well-balanced diet. Children aged 6–24 months are considered to be at the greatest nutritional risk due to poor feeding practices, with repercussions on their growth and development. Consequently, this age group is at increased risk of morbidity and mortality among young children[1–3].

In developing countries it is difficult to achieve an adequate intake of several nutrients from complementary feeding, which is commonly based on traditional and unfortified foods[4]. Previous studies have suggested that complementary foods are especially limited in micronutrients such as Fe, Zn and Ca[1,4].

Fe deficiency, the most common and widespread nutritional deficiency worldwide[3], has been strongly related to dietary inadequacies during the first 2 years of life. In addition, in this critical period when the switch from a predominantly milk-based diet to one based on solid foods occurs, the increased risk for Fe deficiency is related to higher Fe requirements for growth and the depletion of Fe stores in this age group[5].

Adequate assessment of feeding practices in children under 2 years of age requires data on breast-feeding patterns, dietary intakes and nutritional status indicators[6]. To date, the relationship between biochemical Fe status, anthropometrical indicators and dietary intakes of young children in Amazonia has not been investigated. The only previously published survey on risk factors for anaemia and Fe deficiency in an Amazonian population did not assess food intakes[7]. Here we present an exploratory study about food intake and nutritional status of a randomly selected sample of 0–24-month-old children living in two towns in the Brazilian Amazon.

Methods

Survey design and population

In January 2003, a population-based cross-sectional study on child health and nutrition was carried out in the towns of Acrelândia and Assis Brasil, located respectively 350 km and 100 km from Rio Branco in the state of Acre, north-west Brazil. Subsistence agriculture and cattle-raising

*Corresponding author: Email marlyac@usp.br

are the main local activities; coffee and banana are the predominant cash crops.

In these towns, all households with children less than 5 years of age were identified by a census performed by our field team. All eligible children were invited to participate in the main study. Data collected from 491 households (334 in Acrelândia and 157 in Assis Brasil) were available (100 % of eligible households). Sampling strategies and results of the survey are reported elsewhere[8].

The survey included a structured face-to-face interview, usually with the child's mother, carried out by trained field workers. Questionnaires inquiring about socio-economic and demographic conditions, household environment, birth condition, breast-feeding initiation and morbidity during childhood (diarrhoea) were completed for 724 children. Diarrhoea occurrence was defined as the passage of frequent loose or liquid stools in the 15 d prior to the survey as reported by the child's caregiver, and was categorised as 'yes' or 'no'. Of the interviewed children, 677 provided blood samples (94 % of those eligible) and comprised the population further analysed in the main study.

Owing to limited resources, we decided to select at random a sub-sample of households with children below 2 years of age. Of the 250 children aged <2 years in the main study, 30 % (seventy-five participants) were randomly selected with stratification by sex in each town to collect detailed information about breast-feeding and complementary feeding practices. The study was approved by the ethical review board of the School of Public Health of the University of São Paulo, Brazil. Written informed consent was obtained from the primary caregiver for each child participating in the study.

Anthropometry

Length and weight were measured by trained research assistants following standardized procedures and using calibrated equipment[9]. Recumbent length was measured on an infant measuring board (model 98-702; Seritex, Carlstadt, NJ, USA) and recorded to the nearest 0·1 cm. Weight was taken on a digital paediatric scale (Soehnle, Murrhardt, Germany) and recorded to the nearest 0·05 kg. Each measurement was repeated and the mean value was calculated. Birth date was recorded directly from the birth certificate or child health card.

The *Z*-scores for length-for-age (LAZ), weight-for-age (WAZ) and weight-for-length (WLZ) were calculated using the DOMEANS procedure in the EPI-Info software version 6·04 (Centers for Disease Control and Prevention, Atlanta, GA, USA)[10]. Anthropometric cut-offs were analysed according to Onis *et al.*[11].

Fe nutritional status

A fasting venous blood sample was collected from each child. Hb concentration was measured using a HemoCue photometer (HemoCue AB, Angelholm, Sweden) at the study site. Serum samples were then transported on dry ice to São Paulo, where concentrations of serum ferritin (SF) and soluble transferrin receptor (sTfR) were measured using commercial enzyme immunoassay kits (Ramco Laboratories, Houston, TX, USA). The normal range of sTfR levels determined by the manufacturer was 2·9–8·3 mg/l.

Anaemia, Fe deficiency and Fe-deficiency anaemia were defined on the basis of Hb, SF and sTfR values. Anaemia was defined according to the WHO cut-off value for children >6 months of age (Hb concentration <11·0 g/dl). Fe deficiency was diagnosed when SF < 12 μg/l and sTfR > 8·3 mg/l. The definition for Fe-deficiency anaemia was identical, except Hb had to be <11·0 g/dl for children >6 months of age[3,12]. Anaemic children detected during the survey received adequate treatment with ferrous sulfate, prescribed by the medical team involved in the project.

Breast-feeding and complementary feeding practices

Breast-feeding and complementary feeding practices were evaluated by trained nutritionists. The dietary intakes of the infants and toddlers were obtained using a diet history tool[13]. Weighed food portions were obtained using accurate scales (precision 1 g) to derive the recipes mentioned in the diet history. This methodology permitted estimation of the quantity of different foods used in the recipes. The use of diet history data enabled minimization of the day-by-day variability, where instead of asking the caregiver 'What did the child eat yesterday?', the question was 'What does the child usually eat?'. The intake of breast milk volume was estimated using the following formula developed from children living in developing countries[14,15]: $Y = 489 - 0{\cdot}63X + 13{\cdot}45Z$ (where Y is the predictor of breast-feeding intake in ml/d, X is the age in months and Z is the number of breast-feeding episodes during the day).

The database of the World Food Dietary Assessment System (WFood version 2·0; Office of Technology Licensing, University of California at Berkeley, Berkeley, CA, USA) was used to estimate the nutrient composition of diets. The nutrient database was based on the US Department of Agriculture (USDA) publications supplied by WFood, selecting databases for Mexican and Kenyan foods. All components (phytate, animal protein, Ca, tannin and ascorbic acid) necessary to estimate Fe and Zn bioavailability were included in the analyses. Since the Brazilian Food Composition Table is incomplete for many chemical components of interest, its use was limited to cooked beans (with broth) and non-enriched maize flour that could not be matched with foods from the WFood databases.

Using the WFood software, Zn bioavailability was calculated based on body basal requirements[16]. The bioavailability of haem Fe was calculated using the FAO/WHO estimate of 25 %[15]. For non-haem Fe, bioavailability was determined for each meal as previously described[1]. Daily energy and nutrient intakes from complementary foods and breast milk were compared with estimated needs determined in a recent review by Dewey and Brown[6,17]. Values for the nutrient composition of breast milk were derived from the USDA database[18].

Classification of breast-feeding categories was based on WHO criteria[19] as follows. (i) Exclusive breast-feeding: only breast milk (including milk expressed or from a wet-nurse), does not allow the infant to receive anything else, only drops and syrups; (ii) predominant breast-feeding: breast milk (including milk expressed or from a wet-nurse) as the predominant source of nourishment, allows liquids, ritual fluids and drops or syrups; or (iii) breast-feeding: breast milk, allows any food or liquid including non-human milk.

Statistical methods

Variables are presented as proportions (%), means (standard deviation) and medians (interquartile range) and were compared using χ^2 tests, *t* tests, ANOVA and Mann–Whitney tests. Information on the ownership of thirteen household assets was used to derive a wealth index; a derived variable used as a proxy of income in the domiciles. For this, principal components analysis was used to define the weights of household assets[20] using the XLSTAT software version 7·5·2 (Addinsoft, New York, NY, USA). The first principal component explained 32·7 % of the variability and gave the greatest weight to the ownership of a blender (0·345), a washing machine (0·327) and a refrigerator (0·311). After standardization of these weighted asset variables, the highest scores were associated with the ownership of a videotape player/recorder (2·865), a car (2·835) and a telephone (1·350). The lowest scores were given to households without a gas stove (−4·141), a refrigerator (−1·876) and a television (−1·833). The asset scores were summed to a wealth index for each household, which was divided into tertiles for further analysis. Frequencies of anaemia, Fe deficiency, Fe-deficiency anaemia and stunting were compared across tertiles of the wealth index.

The children were grouped into three age categories: infants (0–5 and 6–11 months) and toddlers (12–24 months). Due to non-normal distributions, dietary variables are expressed as median values and interquartile ranges according to age group. Proportions of children who met the recommended nutrient intakes[17] were compared according to the wealth index tertiles. The dietary intakes were adjusted for total energy intake using the residual method[21]. Then, the median values for Hb and SF concentrations across tertiles of energy-adjusted nutrient intake levels were calculated. Frequencies of anaemia, Fe deficiency, Fe-deficiency anaemia and stunting were also compared across tertiles of energy-adjusted nutrient intakes.

Statistical analyses were performed using the SPSS statistical software package version 12·0 (SPSS Inc., Chicago, IL, USA). All *P* values were two-tailed and $P < 0.05$ was the level of significance.

Results

Among the seventy-five children enrolled in the present study, sixty-nine had complete information on the diet history questionnaire (27·6 % of the total children under the age of 2 years in the main study). Of them, 50·7 % (*n* 35) were male. The mean (SD) age was 13·4 (6·6) months. Twenty-five children (33·3 %) were living in Assis Brasil and forty-six (66·7 %) in Acrelândia. Among the heads of the family, 8·1 % had never studied at school, 14·7 % had studied for <4 years and 45·9 % had between 4 and 8 years of formal education. In both towns there was no sanitation system. Overall, breast-feeding was initiated by 97·1 % of mothers, and twenty-six children (37·7 %) were breast-feeding at the time of the study. Among infants aged 0–5 months, only two (16·2 %) were exclusively breast-fed. The frequencies of breast-feeding according to age group were 66·7 % at 0–5 months, 50·0 % at 6–11 months and 23·1 % at 12–24 months. Low prevalence (4·3 %) of low birth weight (<2500 g) and high prevalence of recent diarrhoeal episodes (39·1 %) were observed.

There were no significant differences in sociodemographic variables of the study children living in Assis Brasil and Acrelândia (Table 1). Table 2 presents characteristics of the nutritional status of the children according to age group. Overall, 69·7 % of the anaemia cases were due to Fe deficiency. A higher proportion of Fe deficiency was observed among toddlers (12–24 months) than among infants aged 6–11 months (χ^2, $P < 0.05$). Mean values of anthropometric indices were in the normal range for infants (0–5 and 6–11 months) and toddlers, without differences in these means according to age group (ANOVA, $P > 0.05$). The frequencies of morbidities (anaemia, Fe deficiency, Fe-deficiency anaemia,

Table 1 General characteristics of the children according to town, Acre, north-west Brazil

	Assis Brasil (*n* 23)		Acrelândia (*n* 46)	
Variable	*n*	%	*n*	%
Gender				
Male	11	47·8	24	52·2
Female	12	52·2	22	47·8
Age groups (months)				
0–5	3	13·0	9	19·6
6–11	7	30·4	11	23·9
12–24	13	56·5	26	56·5
Paternal schooling (years)				
None	1	4·3	4	8·7
1–4	4	8·7	14	35·0
>4	16	76·2	22	55·0
Inhabitants per household				
>4·5	9	39·1	18	39·1
Drinking water treatment	18	78·3	29	63·0
Public garbage collection	21	91·3	38	82·6

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Table 2 Nutritional status of the children according to age, Acre, north-west Brazil

	0–5 months (n 12)		6–11 months (n 18)		12–24 months (n 39)		All (n 69)	
LAZ								
Mean	−0·19		0·25		−0·60		−0·32	
SD	1·74		1·35		1·51		1·54	
% of stunting (LAZ < −2)	16·7 (n 2)		0		15·4 (n 6)		11·5 (n 8)	
WAZ								
Mean	−0·24		0·61		−0·18		0·01	
SD	1·24		1·41		1·09		1·24	
% of underweight (WAZ < −2)	8·3 (n 1)		0		7·7 (n 3)		5·8 (n 4)	
WLZ								
Mean	0·01		0·41		0·13		0·18	
SD	0·77		1·08		0·98		0·97	
% of wasting (WLZ < −2)	0		5·6 (n 1)		0		1·4 (n 1)	
% of overweight (WLZ > 2)	0		11·1 (n 2)		0		2·8 (n 2)	
	n	%	n	%	n	%	n	%
Anaemia†	–		9	50·0	14	35·9	23	33·3
Fe deficiency	2	25·0	7	38·9	29	74·3*	36	52·2
Fe-deficiency anaemia†	–		4	22·2	12	30·8	16	23·2

LAZ, length-for-age Z-score; WAZ, weight-for-age Z-score; WLZ, weight-for-length Z-score.
Prevalence was significantly different from that in the other age groups (χ^2 test): $*P<0.05$.
†Only for children >6 months old.

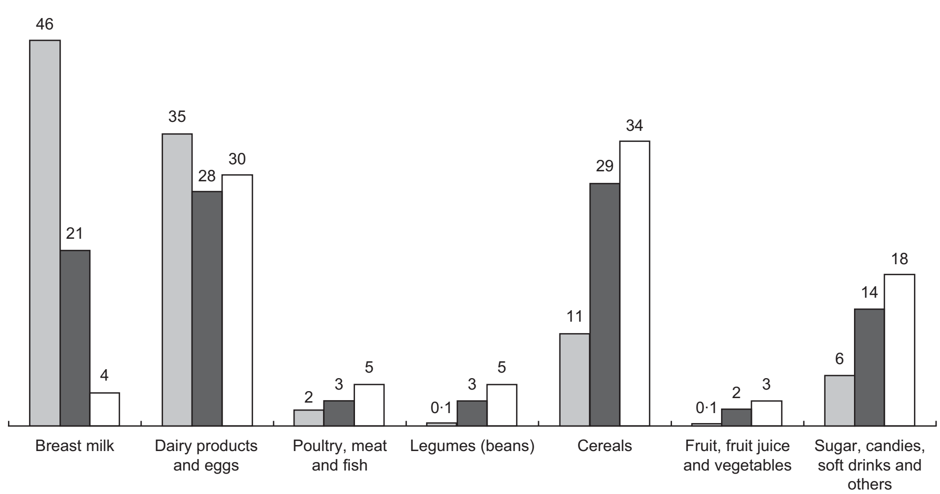

Fig. 1 Contribution (%) of food groups and breast milk to total energy intake among infants (▨, 0–5 months old; ■, 6–11 months old) and toddlers (□, 12–24 months old), Acre, north-west Brazil (n 69)

stunting and diarrhoea) did not differ across tertiles of the wealth index (data not shown).

Figure 1 illustrates the percentage contribution of complementary foods and breast milk (to total energy intake) according to age group. Among infants aged 0–5 months, the major energy contributors were breast milk followed by non-enriched cow's milk. In the groups of infants (6–11 months) and toddlers, the major food contributors to energy, excluding breast milk among infants, were cereals (especially non-enriched rice and maize flours), non-enriched cow's milk and sugar (from soft drinks, artificial juices and that added to porridges). Low intakes of meat, beans, vegetables and fruits were observed for all groups.

The median daily intakes of energy and nutrients, according to age group, are shown in Table 3. Total energy included energy and nutrients provided by breast milk. Compared with international recommendations[6,17], the median intakes of protein, riboflavin, vitamin B_{12} and folate were above the recommendation for all these age groups. Median intakes of ascorbic acid were above the recommendation for infants (0–5 and 6–11 months), while the median intake of thiamin was above the recommended value for children aged >6 months. Median intakes of vitamin A, vitamin B_6 and Ca were above the recommended values only for 0–5-month-old infants, 6–11-month-old infants and 12–24-month-old toddlers, respectively. Median intakes of niacin, total Fe, bioavailable Fe and Zn were under the recommendations for all age groups. All infants and 92·3% of toddlers were at risk for inadequate total Fe intake. Dietary Fe from animal foods contributed on average 0·5% and 14·3% to the total Fe intake among infants and toddlers, respectively.

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Table 3 Median daily intakes of energy and selected nutrients† of the children according to age group, Acre, north-west Brazil

	0–5 months (*n* 12)		6–11 months (*n* 18)		12–24 months (*n* 39)	
	Median	IQR	Median	IQR	Median	IQR
Energy (kJ)	2699	2113, 3421	3515	2458, 3919	4481	3477, 6586
Energy (kcal)	645·0	505·0, 817·7	840·5	587·5, 936·7	1071·0	831·0, 1574·0
Protein (g)	16·0	9·5, 28·6	22·8	17·0, 30·9	35·1	22·7, 50·0
Animal protein (g)	14·8	8·3, 26·2	15·3	11·8, 26·6	23·2	15·4, 35·6
Protein from meat (g)	0·0	0·0, 0·0	0·1	0·0, 6·3	6·6	0·7, 13·0
Vitamin A (RE)	386·0	308·7, 448·7	326·0	232·7, 484·5	320·0	240·0, 568·0
Ascorbic acid (mg)	26·0	21·2, 32·7	28·5	15·7, 51·5	24·0	17·0, 39·0
Thiamin (mg)	0·16	0·1, 0·2	0·25	0·2, 0·36	0·4	0·2, 0·6
Riboflavin (mg)	0·49	0·3, 1·1	0·7	0·53, 0·96	0·95	0·6, 1·6
Niacin (mg)	0·6	0·1, 1·3	1·8	1·0, 2·9	3·7	2·2, 6·0
Vitamin B_6 (mg)	0·17	0·1, 0·33	0·4	0·3, 0·5	0·6	0·4, 1·0
Folate (mg)	35·5	34·0, 49·0	60·0	47·2, 79·5	83·0	62·0, 131·0
Vitamin B_{12} (mg)	0·49	0·36, 1·2	1·1	0·4, 1·8	2·0	0·8, 3·8
Ca (mg)	425·0	240·7, 872·2	492·0	367·0, 638·5	559·0	453·0, 895·0
Fe (mg)	0·64	0·4, 1·0	1·6	0·9, 2·3	2·8	2·0, 4·8
Fe from animal foods (mg)	0·0	0·0, 0·0	0·01	0·0, 0·4	0·4	0·09, 0·9
Bioavailable Fe (mg)	0·02	0·005, 0·07	0·1	0·05, 0·30	0·3	0·2, 0·6
Zn (mg)	2·2	1·4, 3·8	3·1	2·1, 3·8	4·7	3·0, 6·9
Bioavailable Zn (mg)	1·4	1·2, 2·2	1·5	1·1, 2·1	1·7	1·1, 2·8

IQR, interquartile range; RE, retinol equivalents.
†Including energy and nutrients provided from breast milk.

A non-significant trend was found in which median values for Hb and SF concentrations increased with increasing tertile of energy-adjusted vitamin A (10·8, 11·3, 11·6 g/dl for Hb; 7·0, 8·5, 13·0 μg/l for SF) and total Fe intakes (11·1, 11·3, 11·4 g/dl for Hb; 13·0, 7·5, 9·3 μg/l for SF), comparing the lowest to the highest tertiles, respectively (*P* for trend >0·05). Frequencies of anaemia, Fe deficiency and Fe-deficiency anaemia were not statistically different across tertiles of energy-adjusted nutrient intakes. However, five of the eight cases of stunted children were in the lowest tertile of energy-adjusted vitamin A intake. The energy-adjusted bioavailable Fe intake was statistically different across tertiles of the wealth index: 0·170, 0·198 and 0·233 mg/d, comparing the lowest to highest tertiles, respectively (*P* for trend = 0·043).

Discussion

Our findings should be interpreted cautiously because there are some limitations to the present study. The principal constraint of our study is the cross-sectional design and the small sample size. Thus, we cannot establish a temporal relationship between dietary practices and nutritional status. However, this is the first nutritional survey to assess biochemical Fe status, anthropometric indicators and dietary practices in a randomly selected sample of children under the age of 2 years living in the Brazilian Amazon area. Although Acrelândia and Assis Brasil are examples of Amazonian towns with distinct economic activities, they show very similar childhood health indicators[8]. In Brazil, the state of Acre has the second worst childhood development index, with a childhood mortality rate (34·3/1000) higher than that observed for Brazilian children overall (27·7/1000)[22].

We have not found differences in the frequency of stunting according to tertile of energy and nutrient intakes, except only for energy-adjusted vitamin A intake (with a high proportion of stunting in the lowest tertile of intake). Stunting prevalence in our children (11·6 %) was lower than the values reported in other studies in developing countries, but it should not be neglected[23,24]. A previous study carried out in Latin America[25] found the association between feeding practices and stunting to be generally weaker and less consistent among children during the first year of life, increasing gradually with age. The magnitude of this association was greatest among 30–36-month-old children. An additional factor that may explain the greater effect of feeding practices on height-for-age among older children is the clustering of negative practices and behaviours, with their cumulative effect becoming apparent only after a certain age, possibly starting during the second year of life and likely increasing over time[26].

In the present study, the haematological indicators showed a high prevalence of anaemia, Fe deficiency and Fe-deficiency anaemia among the children. Overall, 30·3 % of the anaemic children did not show evidence of Fe deficiency. Other nutrient deficiencies could be the cause based on the presence of low dietary intakes of vitamins, especially vitamin A. Unfortunately we did not assess other biochemical indicators that could elucidate the origin of the remaining anaemia. The percentage of anaemia found among these under-twos from Acre was similar to the values reported by WHO[3] for children from developing

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countries. Higher prevalences of anaemia and Fe deficiency were reported among under-twos in a rural community of South Africa: 65·2 % and 43·2 %, respectively[23]. However, in our study the prevalence of anaemia and Fe deficiency was higher than that observed in infants from developed areas. In a longitudinal study of under-twos in Dunedian (New Zealand), Fe deficiency was observed in 7 % of children at 9, 12 and 18 months, and it was absent at 24 months of age[26]. Contrary to the results from Heath *et al.*[26], we found a significant increase in the prevalence of Fe deficiency in toddlers compared with infants.

In our study population, exclusive breast-feeding was interrupted in 83·8 % of the infants <6 months of age, with early introduction of complementary foods. The frequency of exclusive breast-feeding found in the present study was lower than the prevalence observed in a national sample of 0–5 month-old Brazilian children[27]. The nutritional value and protective immune properties of breast milk as well as the psychosocial benefits of breast-feeding to the infant are widely recognized. Thus the WHO[3] recommends exclusive breast-feeding during the first 6 months, followed by introduction of additional foods to meet the child's nutrient needs. However, early introduction of complementary food is still a common practice in many developing countries, and the inclusion of non-breast-milk foods and beverages in the child's diet before the age of 6 months increases the risk for nutrient imbalances/deficiencies and infectious diseases[28,29]. A longitudinal study realized with Vietnamese children concluded that over the age range from 1 month to 4 years, *Z*-scores for all anthropometric indices (weight-for-age, height-for-age and weight-for-height) of the children who received complementary food were significantly lower than those of the children who were exclusively breast-fed for at least 3 months. In the same study, morbidity from diarrhoea and acute respiratory infections was significantly lower for the >3 months exclusively breast-fed group, compared with the group that was exclusively breast-fed for <3 months[30]. Similar results were found by Victora *et al.*[28] in a population-based case–control study carried out in two urban areas in Brazil, reporting that the type of milk in an infant's diet was an important risk factor for death from diarrhoeal and respiratory infections. We found a high prevalence of recent diarrhoea (39·1 %) among our children that may be due to the combined effects of reduced time of exclusive breast-feeding, early introduction of complementary foods, and crowded and unsanitary living conditions[8] (subjects' domiciles often had high a number of people per bedroom and lacked a sanitation system).

Analysis of food group intakes showed a high content of carbohydrates and porridges made from cow's milk and non-enriched flours and of low quantities of meat, vegetables and fruits. Faber and Benadé[23] and Hotz and Gibson[1] found similar food intake patterns among infants and toddlers from rural areas in South Africa and Malawi, respectively. In these studies, mostly carbohydrates and less frequently fruits, vegetables, meat, Fe, vitamin A and vitamin C contributed to the energy content of complementary diets. In our study, cow's milk intake represented 35·2 %, 28·1 % and 30·0 % of the total energy consumed by infants (0–5 months), infants (6–11 months) and toddlers (12–24 months), respectively. A Brazilian national survey[27] showed among 0–5-month-old and 6–12-month-old children that the presence of other milks in the complementary feeding (excluding breast milk) was 51·1 % and 73·1 %, respectively. Several studies have already shown the deleterious effect on Fe nutritional status of the introduction of cow's milk in the diet of the under-twos[5,29,31]. Soh *et al.*[5] found among 6–24-month-old New Zealanders receiving >500 ml cow's milk/d that there was a decrease of 25 % in SF values. Another Brazilian study showed a significant positive association between cow's milk intake and anaemia risk among children <5 years old and reported a possible inhibitory effect of cow's milk on the absorption of Fe from other foods[31].

Low contents of Fe, bioavailable Fe and vitamins C and A observed in the complementary feeding adopted by our children were also observed in other studies from developing countries, where feeding practices based on cereals and legumes negatively influence Fe bioavailability from plant-based complementary foods, with relatively high amounts of phytic acid and negligible amounts of ascorbic acid[32]. The intake levels of bioavailable Fe were positively associated with the wealth index in our study population, suggesting that socio-economic improvements can have some impact on the quality of children's diet in this setting. Low intakes of total Fe and bioavailable Fe can be the cause of the high rates of Fe deficiency observed in our study population. Another cross-sectional study[5] investigated food sources and dietary factors associated with SF levels in 6–24-month-old children and found that intakes of total Fe (from diet and supplemented) and vitamin C were positively associated with SF levels, after controlling for possible confounders.

Similar to previous studies carried out in other developing countries[1,4,23], we found low intakes of Ca and Zn, where the median intake of Ca was above the recommendation only for toddlers. There is no conclusive evidence showing that suboptimal Ca intake leads to a clinical or subclinical deficiency state or contributes to linear growth faltering[1]. The most convincing evidence for the role of a specific nutrient deficiency in causing linear growth faltering among young children has been reported for Zn deficiency[33].

Given the detrimental consequences of early childhood malnutrition for health and development, there is an urgent need to promote exclusive breast-feeding in the first 6 months of life and to improve complementary feeding. From our results we highlight that it is necessary to conduct nutritional education and intervention programmes addressing dietary micronutrient deficiencies, especially focusing on complementary diets with high bioavailable Fe content. Additionally, the recommendation for exclusive breast-feeding in the first 6 months of life should be reinforced and action to improve the dietary bioavailability of Zn, Fe and other nutrients should be taken.

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