Hemoglobin concentration, breastfeeding and complementary feeding in the first year of life

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Abstract

Objective
To assess the relationship between hemoglobin concentration and breastfeeding and complementary feeding during the first years of life.
Method
Cross-sectional study with 553 children under age 12 months, who attended public healthcare facilities. Hemoglobin concentration was measured by the cyanmethaemoglobin method, using the HemoCue system. Associations of interest were analyzed through multiple linear regression.
Results
Hemoglobin concentrations compatible with anemia were identified in 62.8% of the children studied, with greater occurrence among the 6-12 months age group (72.6%). Exclusive breastfeeding during the first six months of life was associated with the highest levels of hemoglobin. The remaining feeding regimes were associated with different levels of reduction in hemoglobin levels, which became compatible with anemia in children fed with formula (p=0,009). Tea and/or water consumption was associated with a reduction in hemoglobin concentration of 0.76 g/dl (p<0,001) among children under age 6 months. For children aged 6-12 months, hemoglobin concentrations increased significantly with the consumption of sugar (p=0.017) and beans (p=0.018), and decreased significantly with the consumption of fruit (p<0.001).
Conclusion
Exclusive breastfeeding until age 6 months and continuation of breastfeeding after this age, combined with qualitatively and quantitatively appropriate feeding may contribute towards an increase in hemoglobin concentration in the first year of life.

INTRODUCTION

Anemia is a highly prevalent disease worldwide, but rates are highest in developing countries (ACC/SCN,[1] 1997). Several factors, including low consumption of iron-rich foods, parasitic and infectious diseases, genetic background, and interactions with other micronutrients may impair normal hemoglobin synthesis. However, in areas where the prevalence of anemia is high (above 50%), the most common cause of this condition is the low bioavailability of dietary iron (ACC/SCN,[1] 1997). In spite of the existence of several indicators for diagnosing anemia at the population level, the indicator most frequently used is hemoglobin concentration, with its specific cutoff points for different age groups and physiological conditions (WHO,[19] 2001).

Pregnant women and children during growth stages are the groups most vulnerable to iron deficiency anemia. The highest prevalence is detected among children in the 6 to 24 month age group, a period which coincides with the termination of breastfeeding. There is also evidence that the occurrence of

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anemia decreases as the child grows, even though anemia is still an important health problem among preschool children (ACC/SCN,[2] 2000).

Recent studies conducted in various Brazilian capitals show an increasing trend in the prevalence of anemia among preschool children (Monteiro et al,[10] 2000; Oliveira et al,[11] 2002). In epidemiological terms, these are important results, since anemia has negative effects on psychomotor development and child learning (ACC/SCN,[2] 2000) and depresses the immune response (Scrimshaw & SanGiovanni,[13] 1997).

Major factors contributing to the decline of hemoglobin levels during the first year of life include low fetal iron reserves and short duration of breastfeeding. These are combined with the consumption of foods of low energetic density and limited iron content, whose effects are furthered by the high concentration of components that inhibit iron absorption, normally present in special transitional foods and/or family foods (WHO,[17] 1998).

Human milk, a source of highly bioavailable iron, is offered to most children until the third or fourth month of life. It is generally combined with cow's milk, which, in addition do its low content of bioavailable iron, also promotes small-scale blood loss by damaging the intestinal mucosa and causing the appearance of micro-hemorrhages (ACC/SCN,[1] 1997). Thus, cow's milk may contribute towards the decline of hemoglobin levels. Studies indicate that low levels of hemoglobin are also associated with precarious living conditions and with inadequate sanitary conditions in the area of residence (ACC/SCN,[1] 1997).

The present study was designed to evaluate the relationship between hemoglobin concentrations and the consumption of breast milk, complementary foods, and other liquids during the first twelve months of life.

METHODS

This cross-sectional study is part of a larger project, called "Breastfeeding, breastfeeding-termination diets, and anemia during the first year of life in children attending the public healthcare network."

The sample comprises 553 infants who attended public healthcare facilities in the city of Salvador, Bahia, in northeastern Brazil, between July 1998 and August 1999. The sample has a 90% power (1-β) to detect a 20% prevalence of anemia with a 0.05 significance level (1-α). Children were recruited by in three such facilities, during growth control and/or vaccination visits. In case hemoglobin levels compatible with anemia were detected, the mother and/or guardian were informed about nutritional therapy and, if necessary, drug treatment was initiated. Mothers who agreed that their children participate in the study signed a term of consent, as determined by Statute 196/1996 of the National Health Council.

Hemoglobin concentration was determined in the field by the cyanmethaemoglobin method, using the HemoCue system (WHO,[19] 2001), considered as reliable and recommended for the determination of hemoglobin concentration during fieldwork.

In case hemoglobin levels were below 9 g/dl of blood, a second dosage was performed and the mean of the two measurements was adopted as the final value. Blood collection was done by fingertip lancing, using disposable lancets.

Weight and length were measured twice by properly trained nutrition students, under the supervision of the research team. Microelectronic *Filizola* scales, model E-150/3P were employed. Length was measured using a wooden infantometer, the reproducibility of which has been tested in other studies by our group.[5] An error of up to 100 g and 0.1 cm was tolerated in weight and length measurements, respectively (WHO,[16] 1995). The mean of both measurements was used as final value. Children were weighed without clothing.

The instruments used in anthropometrical evaluation were adjusted before each series of measurements (OMS,[12] 1983). Data relative to weight and length at birth were obtained from the child's birth certificate or child card. Weight-for-age and height-for-age (in z-scores) were adopted for characterizing the child's anthropometric status.

Information on the child's regular food consumption were obtained at the time of the interview from the mother or guardian, based on a list of previously selected foods. Based on this information, children were assigned to one of seven groups, according to the feeding pattern adopted: 1) exclusive breastfeeding: children who were fed exclusively breast milk – only medication and mineral or vitamin supplements were allowed in this group; 2) predominant breastfeeding: children who were given breast milk supplemented with tea and/or water; 3) complemented breastfeeding: children who were given breast milk and other foods, excluding any other types of milk; 4) mixed milk feeding: children who were given breast and cow's milk and who did not consume any other type of food; 5) complemented mixed milk feeding: children who consumed breast and cow's milk and other foods; 6) artificial milk feeding: children who were fed exclusively cow's milk and did not consume any other type of food; and 7) complemented artificial milk feeding: children who were given exclusively cow's milk and not breast milk, complemented by other foods. The number of formula-fed infants was too small for a separate analysis to be conducted. Therefore artificial milk feeding included both formula and cow's milk.

Mean values were used to describe the distribution of hemoglobin levels according to the variables of interest. The Dunnet test was used to evaluate the statistical significance of the differences between means. Multiple linear regression was employed to evaluate the association between hemoglobin levels and food consumption profile and to explore the association between mean hemoglobin levels and the different types of feeding patterns. The significance level adopted for keeping variables in the model was 0.10. Associations with significance levels below 0.05 were accepted.

Considering that the food consumption of children under age six months differed, in both qualitative and quantitative terms, from that of children aged 6 to 12 months, we chose to analyze data separately for each of these groups. For children under age 6 months, exclusive breastfeeding was adopted as a protective factor; all consumption of other foods was considered as undesirable due to the possibility of being associated with anemia. For children 6 months or older, breast milk as the only type of milk, associated with complementary foods, was adopted as the reference. The consumption of any type of cow's milk was interpreted as a predisposing condition for the development of anemia.

A linear regression model was adopted in order to evaluate the relationships of interest; thus, hemoglobin level was included in the model as a continuous dependent value. Sex, anthropometric indicators, (categorized as <-2.0 and =-2.0 z-score standard deviations (SD), child's age (continuous variable, squared when indicated), duration of gestation (categorized as <37 and =37 weeks), birthweight (categorized as <2,500 and =2,500 g), and maternal schooling (categorized as incomplete elementary (1st – 8th grades) and complete elementary or more – used in the present study as a proxy of the living conditions of children and their families) were included in the model for adjustment. When appropriate, categorized variables were transformed into their respective dummies. The main independent variables relative to food consumption were categorized as yes/no variables. Only those foods whose consumption frequencies were above 10% were included in the regression model.

In order to avoid the effects of colinearity in the statistical model, certain food items were excluded from the analysis. Thus, for children under six months, meat was excluded from the statistical model; for children older than six months, bean broth was excluded, and beef broth and bean grains were included instead. This exclusion was based on prior knowledge of the consumption patterns of infants in the city of Salvador (Assis et al,[5] 2000).

Multicolinearity was evaluated by factor inflation variance (VIF) and tests of normality were carried out using the Kolmogorov-Smirnof test; the homogeneity of variance was evaluated by residual analysis (Armitage & Berry,[4] 1997). Statistical analysis was carried out using SPSS for Windows v. 10 software. Anthropometric status evaluation was carried out using Anthro 1.02 software.

The protocol of the present study was submitted to and approved by the Ethics Committee of the *Hospital das Clínicas da Universidade Federal da Bahia*.

RESULTS

Mean hemoglobin levels differed significantly according to age group (p<0.001), sex (p=0.014), anthropometric status expressed by weight-for-age (p=0.002), duration of gestation (p=0.004), and birthweight (p<0.001). The mean hemoglobin level among the children studied was 10.65 g/dl (SD=1.989). Hemoglobin levels compatible with anemia (<11.0 g/dl) were detected in 62.8% of children, with greater occurrence among children six months or older (72.6%) (Table 1).

Highest hemoglobin concentrations were observed among exclusively breastfed children, followed by those predominantly breastfed. The mean hemoglobin levels of children fed according to the remaining patterns were significantly lower than those of exclusively breastfed children (p< 0.05). Even though the mean hemoglobin level estimated for the predominant breastfeeding pattern was not compatible with anemia, it was not significantly different from those of the other feeding patterns (Table 2).

Of the children investigated, 97.6% had been breastfed at least once in their lifetimes. However, before these children reached age six months, , this prevalence declined to 80.2%, and 32.2% of these children were already being given dried whole milk or milk formula. Cow's milk in its natural form has little importance in infant feeding patterns; the same pattern was observed with respect to modified formula during the first six months of life (Table 3).

Table 1 – Distribution of mean levels of hemoglobin according to maternal and infant biological characteristics. Salvador, 1999. (N=553)

Variables	N	Mean (g/dl)	SD	p
Age (months)				
< 6	374	10.93	0.101	<0.001
≥ 6	179	10.07	0.145	
Sex				
Male	277	10.45	0.119	0.014
Female	276	10.86	0.119	
Anthropometric indicators				
Weight-for-age (Waz*)				
<-2 SD	17	9.20	0.476	0.002
≥-2 SD	520	10.68	0.086	
Height-for-age (Haz**)				
<-2 SD	34	10.10	0.034	0.097
≥-2 SD	491	10.69	0.090	
Duration of gestation (weeks)				
<37	61	9.97	0.253	0.004
≥37	492	10.74	0.089	
Mother's schooling***				
Incomplete elementary	259	10.61	0.118	0.502
Complete elementary or higher	286	10.72	0.124	
Birthweight				
<2,500 g	59	9.65	0.256	<0.001
≥2,500 g	485	10.78	0.089	

Hemoglobin levels compatible with anemia in the group =62.8%; among children <6 (58.0%) and ≥6 months old (72.6%); mean Z score: Waz =-0.17 (SD=1.22); Haz =-0.27 (SD=1.18).
*16 cases lacking information; **28 cases lacking information; ***eight cases lacking information.

Feeding mode before age six months was based predominantly on breast milk, although tea, water, starches, fruit, and dried whole –milk or milk -formula were already present. After this age, major foods consumed were fruit, vegetables, dried whole milk, cereals and derivatives (rice/pasta, bread, biscuits), starches, sugar, beef, chicken, liver, and beans (Table 3).

The results of regression diagnostic procedures indicated the appropriateness of multiple linear regression for exploring the associations of interest. All VIF values were below 3 and none were below 1, which indicates the absence of multicolinearity between independent variables. The results of residual analysis indicated the appropriateness of the exclusion of five cases whose hemoglobin levels were above 3 (four cases) and below –3 (one case) standard deviations from the group mean for adjustment purposes. In order to make variances homogeneous, age was introduced into some analyses as a quadratic variable.

Multiple linear regression for the evaluation of the behavior of hemoglobin levels according to the types of feeding patterns at the time of the interview was processed only for children younger than six months. In this case, exclusive breastfeeding was used as a reference (Table 4). The results, after control for potential confounders, indicate that, during the first six months of life, of the patterns analyzed, exclusive breastfeeding was the only one to ensure higher levels of hemoglobin (β=11.98 g/dl; p<0.001). All remaining feeding patterns reduced hemoglobin levels in this age group. The predominant breastfeeding pattern was also associated with a 0.73 g/dl reduction in mean hemoglobin levels (p=0.015), even though these levels remained above the cutoff point for the characterization of anemia (Hb=11.25 g/dl). It was also observed that when breastfeeding was maintained in the child's diet but was complemented with other foods (complemented breastfeeding pattern), hemoglobin levels fell 1.02 g/dl (p=0.009).

Cow's milk and breast milk combined (mixed milk feeding pattern) reduced hemoglobin levels by 0.67 g/dl (p=0.44). Artificial milk feeding caused a 1.21 g/dl reduction (p=0.009). The complemented mixed milk and complemented artificial milk patterns caused reductions of 0.52 g/dl (p=0.152) and 0.55 g/dl (p=0.157)

Table 2 – Mean distribution of hemoglobin levels among infants according to feeding pattern. Salvador, BA, 1999. (N=374)

Feeding pattern*	Mean hemoglobin levels		
	N	Mean (g/dl)	SD
Exclusive breastfeeding	37	11.83	0.208
Predominant breastfeeding	39	11.17	0.221
Complemented breastfeeding	26	10.37*	0.247
Mixed milk feeding	28	10.95*	0.261
Complemented mixed milk feeding	37	10.27*	0.164
Artificial milk feeding	14	10.31*	0.405
Complemented artificial milk feeding	35	10.07*	0.165
Total	216		

*Difference between means is significant when compared to exclusive breastfeeding (p<0.05), Dunnet's test.

Table 3 – Percentage distribution of consumption of selected foods according to age. Salvador, BA, 1999. (N=553)

Feeding (%)	Age in months <6		6 a 12		Total	
	N	%	N	%	N	%
Breast milk*	300	80.2	103	57.5	403	72.9
Dried whole milk	121	32.4	151	84.4	272	49.2
Modified formula	59	15.8	1	0.6	60	10.8
Natural cow's milk	12	3.2	22	12.3	34	6.1
Starches	130	34.8	139	77.4	269	48.6
Water and tea	288	77.0	176	98.3	464	83.9
Sugar	140	37.4	137	76.5	277	50.1
Beef broth	23	6.1	122	68.2	145	26.2
Beef	14	3.7	115	64.2	129	23.3
Chicken	14	3.7	123	68.7	137	24.8
Liver	7	1.9	92	51.4	99	17.9
Fish	6	1.6	85	47.5	91	16.5
Egg yolk	5	1.3	95	53.1	100	18.1
Whole egg	-	-	28	15.6	28	5.1
Bean broth	17	4.5	126	70.4	143	25.9
Beans	4	1.1	91	50.1	95	17.2
Legumes	60	16.0	165	92.2	225	40.7
Vegetables	15	4.0	45	25.1	60	10.8
Rice/pasta	24	6.4	138	77.1	162	29.3
Bread/biscuits	26	7.0	151	84.4	177	32.0
Potato	52	13.9	148	82.7	200	36.2
Fruit	126	33.7	171	95.5	297	53.7

*97.6% of children began breastfeeding

in hemoglobin levels, respectively, but these reductions were not statistically significant when exclusive breastfeeding was taken as a reference.

The results of the analysis of the importance of the consumption of selected foods to the determination of hemoglobin levels in children under six months age are presented in Table 5. It was found that the consumption of tea/water reduces the hemoglobin levels of these children by 0.76 g/dl (p<0.001).

At the time of the interview, only a small number of children aged 6 to 12 months (13.3% of the children in this group) were fed according to the complemented breastfeeding pattern. This limitation prevented an analysis of hemoglobin levels based on the type of feeding pattern adopted, since, for this age group, the complemented breastfeeding pattern should be taken as a reference. Thus only the multiple linear regression analysis was carried out in order to evaluate the association between hemoglobin levels and the consumption of selected foods. In this scenario, mean hemoglobin levels were calculated at 11.47 g/dl (p<0.001). With all other variables maintained in the model, it was found that the consumption of sugar and beans increased hemoglobin levels by 0.70 g/dl (p=0.017) and 0.56 g/dl (p=0.018), respectively. However, it was observed that fruit consumption reduced these levels by 2 g/dl (p<0.001)

It was also found that breast milk consumption by children in the 6 to 12 month age group increases hemoglobin levels by 0.44 g/dl, although, in this case, no statistical significance was found (p=0,07) (Table 5).

DISCUSSION

Hemoglobin levels compatible with anemia (<11 g/dl) were found in 62.8% of children. Occurrence was higher in the 6 to 12 month age group (72.6%), although the percentage detected among children under six months was also high (58%). Our results indicate that this disease constitutes an important health and nutrition problem among infants. According to the World Health Organization, the most common cause of high prevalence of anemia (above 40%) is the lack of dietary iron, which is related to the low consumption of this micronutrient and/or to the high ingestion of inhibitors of iron absorption (ACC/SCN,[1] 1997).

Human breast milk is acknowledged as the appropriate food for the child during the first months of life,

Table 4 – Parameters of multiple linear regression for mean hemoglobin levels, according to the feeding patterns of children under age six months. Salvador, BA, 1999. (N=374)

Feeding patterns	N	β	Standard error	p value
Exclusive breastfeeding*	83	11.98	0.24	<0.001
Predominant breastfeeding	72	-0.73	0.30	0.015
Complemented breastfeeding	36	-1.02	0.39	0.009
Mixed milk feeding	53	-0.67	0.33	0.044
Complemented mixed milk feeding	56	-0.52	0.36	0.152
Artificial milk feeding	22	-1.21	0.46	0.009
Complemented artificial milk feeding	51	-0.55	0.39	0.157

*The exclusive breastfeeding pattern was adopted as a reference; controlled for sex, duration of gestation, mother's schooling, birthweight, and age (squared).

Table 5 – Parameters of multiple linear regression for mean hemoglobin levels and food consumption among infants. Salvador, BA, 1999.*

Variable	β	Standard error	p value
Model 1			
<6 months** (N=374)			
Mean hemoglobin levels	12.04	0.22	<0.001
Water and tea consumption	-0.76	0.24	<0.001
Model 2			
≥6 months*** (N=179)			
Mean hemoglobin levels	11.47	0.52	<0.001
Sugar consumption	0.70	0.29	0.017
Bean consumption	0.56	0.23	0.018
Fruit consumption	-2.00	0.56	<0.001
Breast milk consumption	0.44	0.24	0.07

*Only foods with consumption >10% were included in the analysis.
**Controlled for duration of gestation, mother's schooling, child's sex, birthweight, and age; the exclusive breastfeeding pattern was adopted as a reference.
***Controlled for duration of gestation, mother's schooling, child's sex, anthropometric status based on the height-for-age indicator, and age (squared); the predominant breastfeeding pattern was adopted as a reference.

not only due to its energy, micro-, and macronutrient content, but also because of the protection it confers against diseases (WHO,[17] 1998). Even though the amount of iron contained in human milk is not high, its bioavailability is, and it is thus able to meet the child's needs during the first six months of life (WHO,[17] 1998). From this age on, complementary foods available in the family unit must be added to the child's diet in order to increase the availability of energy and micronutrients, especially iron (WHO,[17,18] 1998; 2000).

The results of statistical analysis, controlled for potential confounders, provide evidence of the beneficial effect of exclusive breastfeeding during the first six months of life, since this pattern maintained the highest levels of hemoglobin (β=11.98 g/dl; p<0.001). Our results are supported by those of other studies (Dewey et al,[8] 1998; Wandel,[14] 1996).

It was found that feeding with cow's milk exclusively (artificial milk feeding) was the feeding pattern associated with the greatest reduction in hemoglobin levels during the first six months of life (β=-1.21; p=0.009). The lowest mean hemoglobin level was observed in these conditions (Hb=10.77 g/dl). Even when cow's milk is offered to the child together with breast milk (mixed milk feeding), hemoglobin levels decreased by 0.67 g/dl (p=0.044). Dried whole milk is the most consumed by the children investigated, regardless of age (49.2%). The diets of 32.4% of children already included dried whole milk before the sixth month of life. Due to the cross-sectional design of the present study, it would not be prudent to attribute anemia to the consumption of cow's milk. However, available information are consistent with respect to the deleterious effect of this type of milk on iron levels, be it by favoring the formation of intestinal microhemorrhages, be it by inhibiting iron absorption, especially when associated with starches known to be rich in phytates, substances that inhibit iron absorption by the intestine (WHO,[17] 1998).

It was also observed that the predominant breastfeeding pattern reduced hemoglobin levels in children under six months by 0.73 g/dl (p=0.015), even though the mean level in this group remained above the cutoff point for characterization of anemia (Hb=11.25 g/dl).

Less favorable results were found for the complemented breastfeeding pattern, which reduced hemoglobin levels by 1.02 g/dl (p=0.009) compared with the levels found in association with exclusive maternal feeding, making them compatible with anemia (Hb=10.96 g/dl).

It was also found that, regardless of the pattern adopted, the apparently harmless consumption of tea and/or water reduced mean hemoglobin levels in 0.76 g/dl (p<0.001). Thus, the exclusion of tea and water from the feeding patterns of children in this age group is justified, not only due to the risk of contamination, disease transmission, and abandonment of breastfeeding, but also due to their association with the reduction of hemoglobin levels. It is possible that the consumption of these items may favor on the child a sensation of gastric plenitude, thus diminishing milk consumption and restricting the ingestion of the energy, micro- and macronutrients necessary for hematopoiesis.

The analysis of the influence of complementary foods in the hemoglobin levels of children aged 6 to 12 months indicates that fruit consumption reduced these levels significantly by 2 g/dl of blood. These results persisted even after control for potential confounders.

As with other consumption patterns during infancy throughout a number of capitals in the country,[9] in Salvador, the complementary feeding is begun with fruit, given at the 10 a.m. or 3 p.m. meals (Assis et al,[5] 2000).

Fruit consumption was reported for 95.5% of all 6 to 12-month-old children investigated. This percentage may be considered as satisfactory, although information on the amount consumed is not available for these children. The results of a study involving a representative sample of preschool children from the city of Salvador indicated that children aged 6 to 12 months consume in average 160.8 g of fruit per day, roughly half of the recommended daily amount. Fruit are given mashed or as fruit juice. Juice usually has large quantities of added water, which implies a preparation of low energetic density (Assis et al,[5] 2000).

Thus, we understand that it would not be prudent to trace a direct relationship between fruit consumption itself and the decline in hemoglobin levels. This relationship may be mediated by forms of preparation marked by low energetic density and by the small amounts of this item that are offered to children.

Among the 6 to 12-month-old children investigated, sugar consumption significantly increased hemoglobin levels by 0.70 g/dl of blood. (p=0.017). The feeding patterns of infants are characterized by the adoption of complementary foods of low energy density and by the maternal restriction of the consumption of added fats (Assis et al,[5] 2000). Hence, one may speculate that the statistical importance found for the consumption of sugar in increasing hemoglobin levels in infants reflects the physiological role played by this nutrient as a supplier of energy, also needed for ensuring hematopoiesis.

Likewise, the consumption of beans significantly increased blood hemoglobin levels in children aged 6 to 12 months (β=0.56 g/dl, p=0.018). Although the iron contained in beans is not highly bioavailable, daily and systematic consumption may ensure adequate iron levels and contribute with a generous amount of energy. Beans are given in the form of broth or grains, usually sifted. Of the 6 to 12-month-old children in the present study, 70.4% consumed bean broth and 50.1% bean grains.

Although breast milk consumption showed a trend towards decline as the child's age increased, its consumption by children aged 6 to 12 months increased hemoglobin levels by 0.44 g/dl (p=0.07). Even though this association was not statistically significant, this result may be invested with biological and epidemiological significance, and may indicate that the return to complemented breastfeeding may contribute to revert the high prevalence of anemia (72.6%) found among children in this age group. At the time of the interview, only 13.3% of children aged 6 to 12 months were following a complemented breastfeeding pattern. On the other hand, 57.5% of these children consumed breast milk but included cow's milk in their diet (data not shown). Dried whole milk is usually associated with starches, placed sixth among the foods most consumed by the children investigated. Starches are rarely fortified with iron, and contain substantial amounts of phytates, which impair iron absorption (WHO,[17] 1998).

The early termination of breastfeeding, the inclusion of dried whole milk in the feeding pattern, and the inadequate choice of preparations, combined with the small amounts of complementary foods given to the child, may partly explain the high prevalence of hemoglobin levels compatible with anemia among the children investigated. This conclusion is supported by consistent information on the ability of the consumption of breast milk in association with complementary foods to meet the child's iron need between ages 6 and 12 months (WHO,[17] 1998).

It is also important to emphasize the evidence for the role of a regulatory response in terms of the absorption of breast-milk iron in children under complemented breastfeeding diets, as indicated by Domellöf et al[6] (2002). These authors observed that the rate of absorption of breast-milk iron among nine-month-old children not supplemented with ferrous sulfate was significantly higher than among those using supplementation.

We understand, therefore, that the strategy to be adopted in order to increase the hemoglobin levels of children fed according to the complemented breastfeeding pattern resides in the qualitatively and quantitatively adequate offering of complementary foods.

Important among the strategies of choice for fighting anemia in early life are the control of events associated with pregnancy and lactation capable of interfering with the child's hemoglobin levels. Thus, maternal anemia during gestation – a highly prevalent event, even in developed countries (WHO,[19] 2001) – and low birthweight (Dewey,[8] 1998) and/or preterm delivery (Allen,[3] 2000), prevent the accumulation of the fetal iron reserves necessary for the first six months of life.

Especially among the children included in the present study, low birthweight (β=-0.87g/dl; p=0.04) showed a significant negative association with hemoglobin levels in children under age six months. Preterm delivery was associated with a 0.71 decrease in hemoglobin levels, but this association was not significant (p=0.06) (data not shown in tables).

Within this range of action, it is important also to control the hemoglobin levels of the lactating mother during the process of lactation. Even though there is no evidence that the iron content in breast milk is a reflection of maternal iron levels (Domellöf et al,[8] 2004), it is a consensus that if lactation is continued after the protective effect of lactational amenorrhea on maternal iron reserves ends, there is an increase in maternal iron requirements. Under these circumstances, it is likely that the iron content in milk is not enough to provide adequate amounts of this mineral to the child (Viteri,[15] 1994). Thus, these conditions may be of epidemiological importance to mothers and their children, and must be considered whenever anemia occurs within the first six months of life, especially among children with high breast milk consumption.

Although the statistical results of the present study have been adjusted for most biological factors likely to interfere with blood hemoglobin levels, adjustment for socioeconomic variables may be considered as limited, given that maternal schooling alone was used as a proxy of socioeconomic conditions. We also acknowledge that, even after the issue of model adjustment is overcome, the design of the present study does not allow us to attribute the anemia found in the children investigated to the early termination of breastfeeding and the consumption of complementary foods and non-nutritive liquids.

Nevertheless, the present results indicate that the total or partial replacement of breast milk with other foods before age six months is associated with reductions in hemoglobin levels. Our results also encourage a reflection about the form of preparation of the complementary foods given to infants, given that the lowest levels of hemoglobin were observed when complementary foods were included in the infant's diet. Thus, prolonging exclusive breastfeeding until age six months and maintaining breastfeeding after this age, combined with the consumption of complementary foods with adequate timing and at appropriate quantities, are strategies that may contribute towards increasing hemoglobin levels during the first year of life.

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