DOI: 10.1590/1413-812320182411.05782018

Relationship between breastfeeding patterns and intake of vitamin A and iron in children 6-12 months

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Abstract *The aim of this study was to analyze the association between breastfeeding type in the first six months of life and intake of vitamin A and iron in children 6-12 months of age. It is a cohort study with 226 children. The type of breastfeeding from 1-6 months of life and the food intake from 6 to 12 months were evaluated. Nutrient intake between groups was compared by the Kruskal-Wallis test. The association between nutrient intake and type of breastfeeding was analyzed by Poisson Regression. Consumption below the recommendation of vitamin A and iron was 33.6% and 67.7%, respectively. Infants exclusively and predominantly breastfed from birth to two months had higher vitamin A intake from 6-12 months of life. Infants who were breastfeeding at 6 months had higher vitamin A intake and lower iron by the bivariate analysis. The group that received mixed feeding and artificial feeding at 1 month and the group non-breastfed at 6 months had vitamin A intake below the recommended from 6-12 month of life. The results reinforce the importance of exclusive breastfeeding in the first six months of life contributing to the higher vitamin A intake. Iron intake was lower among breastfed children, but the bioavailability of this nutrient in breast milk is higher.*

Key words *Breastfeeding, Vitamin A, Iron.*

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Introduction

Infant feeding, from birth to the first year of age, influences child health throughout life[1]. Knowing that breastfeeding is critical for infant feeding, the World Health Organization (WHO) recommends exclusive breastfeeding (EBF) for the first 6 months of life and complementary foods up to 2 years of age[2,3].

Early introduction of complementary foods may shorten breastfeeding duration and cause some nutrients to be poorly absorbed, e.g. vitamin A and iron, leading to the development of nutritional deficiencies[4-6]. Iron and vitamin A deficiencies in children are considered a public health problem[7,8]. Data from the National Demographic and Health Survey (PNDS) show that the prevalence of iron deficiency anemia and vitamin A deficiency among children under five was 20.9% and 17.4%, respectively[9].

The association between breastfeeding in the first six months of life and the formation of healthy eating habits in childhood is still controversial. Studies indicate that breastfeeding has a direct influence on food acceptance in later life[10,11], indicating that children who have been breastfed have greater acceptance of fruits and vegetables[12]. This feeding practice is believed to influence iron and vitamin A intake after the introduction of complementary foods[13]. However, Valmórbida and Vitolo[14] found no association between breastfeeding and later eating practices in childhood. Thus, the objective of this study was to evaluate whether breastfeeding in the first six months of life is related to vitamin A and iron intake in children aged 6 to 12 months.

Methodology

This is a cohort study with children followed up from birth to 12 months of life, conducted between 2011 and 2013. The invitation to participate in the study was performed at the maternity hospital in the city of Viçosa-MG, at the time of birth. The sample consisted of 226 children of both sexes, followed in the Municipal Immunization Departmentof Viçosa-MG. This service is considered a reference for performing the Guthrie test, which facilitated recruitment of mothers for the study.

The inclusion criterion was that the child resided within the city limits of Viçosa, MG. The exclusion criteria were: regular use of medications or some clinical health alteration that could interfere with the nutritional status and alter the child's diet. The sample flowchart is shown in Figure 1.

Follow-up losses were assessed for the possibility of selection bias up to the sixth month of follow-up. No differences were found between followed children and lost children when comparing sociodemographic characteristics, number of prenatal consultations, birth variables such as birth weight and length, and use of pacifier, according to data presented by Fonseca et al.[15] and Carvalho et al.[16].

The sample size was calculated for this study using the OpenEpi Program considering the total number of children (806) born in Viçosa during data collection and the prevalence of outcomes (vitamin A intake below recommendation - 33.3%, and iron - 67.7%, for children 6-12 months). For a 95% confidence level, the sample size calculated was 237 and 249, considering the prevalence of food intake below the recommendation for iron and vitamin A, respectively. The sample (226) of children aged 6-12 months, followed since birth, corresponded to 91% of the largest sample calculated (249 children).

During the interview, a semi-structured questionnaire was applied containing questions regarding the child's birth conditions and socioeconomic status. The consumption of breast milk, infant formulae, and bovine milk was evaluated at the first, second, fourth, and sixth month, when the children were taken to the polyclinic for vaccination.

Mothers or guardians (hardly ever guardians) of the children responded to a 24-hour recall at the 6, 9, or 12 months of life. After the first 6 months of life, only one more meeting was held on the 9th or the 12th month. Therefore, whether there was a difference in the dietary intake of iron and vitamin A was evaluated in children aged 6-12 months, according to the breastfeeding pattern in the first six months of life. Losses during the assessment of food intake occurred due to some mothers not being able to report their children's consumption when they attended daycare centers full time and/or had babysitters.

The breastfeeding pattern definitions used in this study followed the Ministry of Health[2]: *Exclusive Breastfeeding (EBF)* - infant receives breast milk only directly from the breast or pumped, or breast milk from donor sources, and no other solids or liquids except syrups, mineral supplements, or medicines. *Predominant Breastfeeding (PBF)* - infant receives, in addition to breast milk, water or water-based drinks (teas, infusions), and

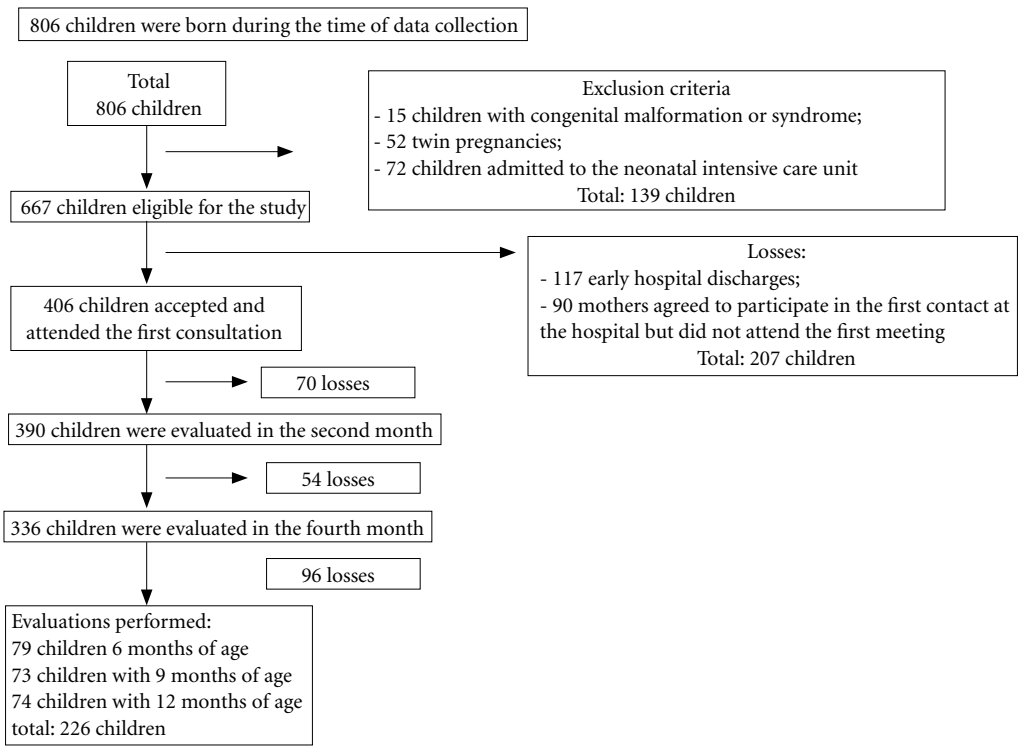

Figure 1. Sample flowchart.

fruit juices. *Complementary feeding* - infant receives, in addition to breast milk, solid or semi-solid foods as a complement to breast milk, not to replace it. *Mixed feeding (MF)* - infant receives breast milk, infant formula, and other types of milk. Due to the low prevalence of *PBF*, we considered the intake values of this pattern together with the *EBF*.

Food intake data were entered into the Avanutri® software. The Food Composition Table (TACO)[17], 4th version, was selected for this study. Foods not found in the program were registered and the ingredient lists were standardized in order not to underestimate or overestimate the amount of vitamin A and iron ingested. Nutrient intake was compared to the Dietary Reference Intakes (DRI)[18]. Vitamin A was quantified in Retinol Equivalent (RE) by the software, but was converted to micrograms for purposes of analysis.

The prevalence of inadequate iron intake was calculated using Adequate Intake (AI) for 6-month-old children (AI = 0.27 mg) and Estimated Average Requirement (EAR) for 7-12-month-old children (EAR = 6.9 mg). Regarding vitamin A, AI = 400 µg was considered for 6 months old children and AI = 500 µg for 7-12 months old children. EAR was used as a reference and when not available, we used AI instead. Nutrients were adjusted by diet energy density using the waste method[19]. This method estimates the fraction of nutrients that do not correlate with total energy intake[20]. We considered the intake of iron and vitamin A from the diet, while the intake of dietary supplements was not taken into account, since it was not included in the recalls.

We estimated the amount of breast milk consumed by the children who were breastfeeding at the time of the food recall application to avoid underestimation of food intake, using the methodology proposed by WHO/UNICEF[21].

We conducted a descriptive analysis to determine measures of central tendency and measures of dispersion. Comparisons between breastfeeding patterns and nutrient intake were analyzed by the Kruskal-Wallis test. The analysis of breast

milk consumption at 6 months was performed by Student's t test.

The bivariate analysis estimated the Relative Risk (RR).The confidence interval was estimated by Poisson Regression with robust variance. Variables with $p < 0.20$ were included in the multiple model. In the regression analysis, the variable food intake was adjusted by current breastfeeding, child age, child skin color, mother's education, and family income. The software application used to analyze the data was Stata version 12.0 and the statistical significance considered was $\alpha = 0.05$.

The study was approved by the Research Ethics Committee of the Federal University of Viçosa, and funded by the Minas Gerais State Research Support Foundation.

Results

In this study, among the children evaluated (n = 226), 50.4% were male, 35.0% were six months of age, 32.3% were nine months of age, and 32.7% were one year of age. We found that 33.6% of children had vitamin A intake below the recommendation, while 67.7% had iron intake below the recommendation. The children's mothers were on average 26 years old and most had more than nine years of schooling (65.0%). Using the socioeconomic classification by ABEP, 78.3% of the families were classified as categories C, D, and E.

Exclusive or predominant breastfeeding in the first month of life was recorded for 77.9% of the children evaluated. These children had higher median vitamin A intake from 6-12 months of life. The median iron intake among children who were exclusively or predominantly breastfed at 1 month was lower than those who were on artificial feeding (AF) (Table 1).

The pattern of breastfeeding the child received at 4 months of life did not interfere with iron and vitamin A intake from 6-12 months of life (Table 2). Breastfed children at six months of age had higher median vitamin A intake and lower iron intake ($p < 0.001$) (Table 3).

The multiple analysis showed that children receiving mixed feeding MF (RR: 1.65; 95% CI: 1.07 - 2.60) and artificial feeding AF (RR: 1.97; 95% CI: 1.10 - 3.58) at 1 month of life, while those who were not breastfed at 6 months (RR: 1.81; 95% CI: 1.10 - 2.99) had a higher risk of vitamin A intake below AI. No significant association was found for iron as a function of breastfeeding pattern (Table 4).

Discussion

This study evaluated the influence of breastfeeding in the first six months of life on the intake of vitamin A and iron in children 6-12 months of age. Infants exclusively or predominantly breastfed at 1 month of life had higher vitamin A intake and lower iron intake after the introduction of complementary feeding. However, no association was found between the pattern of breastfeeding at 6 months and iron intake from 6-12 months of life.

More than a third of the children had lower than recommended vitamin A and iron intake. This prevalence was lower than the reports by Fidelis and Osório[22], which found vitamin A intake below the recommended in 44% of children evaluated in the State of Pernambuco and 59.5% in cities in the metropolitan region of Recife. In the same study, 65% of children had inadequate iron intake in Pernambuco, while 38.1% of children in the metropolitan region of Recife had inadequate iron intake. Freiberg et al.[23] conducted a study in São Paulo and found among children 6-12 months prevalence of vitamin A adequacy of 29.5% and 52.2% for iron intake.

In this study, children who were on mixed feeding, artificial feeding, and no breastfeeding at 6 months of life had a higher risk of vitamin A intake below AI from 6 to 12 months of life. Kurihayashi et al.[24] found a positive association between breastfeeding time and serum retinol concentrations in children aged 2 to 7 years. Children who were exclusively breastfed for a period greater than or equal to 4 months presented higher serum retinol concentration[24].

Fruit and vegetables are the major sources of vitamin A, and some studies indicate a positive association between breastfeeding and consumption of these food groups[10-13]. A longer exclusive breastfeeding and, consequently, a delay in the use of infant formulas, was associated with a higher intake of vegetables at five years of age[25]. This finding is attributed to the variety of flavors in breast milk. Thus, children who are breastfed recognize these flavors later in life and have greater food acceptance[25,26]. In addition, it is expected that mothers who are concerned with following breastfeeding recommendations will also have a healthier lifestyle and pay attention to the recommendation to introduce complementary foods[11,25].

Early introduction of complementary foods is associated with lower nutrient intake and increased vulnerability of children to diarrhea and

Table 1. Median values and interquartile range of nutrient intake from 6-12 months of life, according to breastfeeding pattern offered to children at 1 and 2 months. Viçosa-MG.

Variable	EBF + PBF (n=176)	MF (n = 40)	AF (n=10)
At 1month			
Energy (Kcal)	884.5 (759.3 – 1068.1)a	962.5 (808.6 – 1245.6)b	903.1 (793.5 – 1276.5)ab
Vitamin A (RE)	611.1 (443.5 – 880.0)a	513.1 (253.8 – 778.6)b	265.8 (72.0 – 2010.5)ab
Iron (mg)	4.5 (2.8 – 6.8)a	5.0 (2.7 – 9.0)ab	8.1 (5.8 – 9.8)b
At 2months			
	(n=160)	**(n=40)**	**(n=16)**
Energy (Kcal)	864.3 (737.9 – 1063.3)a	986.5 (861.7 -1216.5)b	953.7 (811.1 – 1081.6)ab
Vitamin A (RE)	605.6 (453.3 – 813.4)a	584.7 (258.6 –1049.8)a	226.2 (75.5 – 749.6)b
Iron (mg)	4.6 (2.7 –7.4)	5.8 (2.7 –9.3)	4.9 (3.3–6.7)

EBF: Exclusive Breastfeeding; PBF: Predominant Breastfeeding; MF: Mixed feeding; AF: Artificial feeding.
Different letters represent statistical significance (P <0.05) by the Kruskal-Wallis test.

Table 2. Median values and interquartile range of nutrient intake from 6-12 months of life, according to breastfeeding pattern offered to children at 4 months. Viçosa-MG

Variáveis	EBF + PBF (n=107)	MF (n =43)	AF (n=19)	Complementary feeding (n = 37)
Energy (Kcal)	863,5 (746,8 –1031,4) a	912,8 (786,6 – 127,2) a,b	973,5 (934,0 – 1184,2) b	921,6 (761,2 -1092,5)a,b
Vitamin A (RE)	603,5 (437,4 – 814,5)	597,6 (275,9 –810,5)	489,0 (101,5 – 153,9)	575,7 (314.5 – 812,3)
Iron (mg)	4,6 (2,6–7,5)	5,4 (3,2 –7,6)	4,9 (1,9 – 7,9)	4,5 (2,7 - 6,6)

EBF: Exclusive Breastfeeding; PBF: Predominant Breastfeeding; MF: Mixed feeding; AF: Artificial feeding.
Different letters represent statistical significance (P <0.05) by the Kruskal-Wallis test.

Table 3. Median values and interquartile range of nutrient intake from 6-12 months of life, according to breastfeeding pattern offered to children at 6 months. Viçosa-MG.

Variáveis	Yes (n = 154) Median (p25 – p75)	No (n =49) Median (p25 – p75)	P value
Energy	874.6 (759.3 – 1026.1)	973.5 (793.5 – 1184.2)	0.065
Vitamin A (RE)	654.7 (492.0 – 941.4)	401.9 (101.5 – 673.2)	< **0.001**
Iron (mg)	4.3 (2.6 – 6.0)	8.9 (5.8 – 10.4)	< **0.001**

Student's t test. Bold numbers indicate statistical significance (P <0.05).

infections, leading to a compromised nutritional status of vitamin A[27]. Children in the present study had lower intake of this nutrient when not breastfed as recommended, being more exposed to the risk of a possible deficiency.

Expenditure on infant formulas is estimated at approximately 35% of the minimum wage, while on bovine milk is at 11%[28]. Breastfeeding is a more economical option for the family, and contributes to that most of the income goes to spending on other foods, especially vitamin A sources such as fruit and vegetables. Therefore, exclusively or predominantly breastfed children would tend to have a better quality diet, with a greater supply of vitamin A source foods[4].

In this study we observed a positive influence of breastfeeding in the first 6 months of life on children's food intake from the beginning of

Table 4. Multiple regression analysis of breastfeeding patterns according to vitamin A and iron intakes below AI and EAR, respectively, in children aged 6 to 12 months. Viçosa-MG.

Variable	RR (IC95%)	p value
Vitamin A (< AI)		
Breastfeeding (1month)		
EBFandPBF	1.00	
Mixed	1.65 (1.07 - 2.60)	0.023
Artificial	1.97 (1.10 – 3.58)	0.022
Breastfeeding (2 month)		
EBFandPBF	1.00	
Mixed	1.55 (1.09 – 2.58)	0.062
Artificial	1.27 (0.84 – 0.91)	0.240
Breastfeeding (4 month)		
EBFandPBF	1.00	
Mixed	1.16 (0.65 – 2.05)	0.615
Artificial	1.06 (0.62 – 1.83)	0.821
Complementary	1.27 (0.80 – 1.99)	0.302
Breastfeeding (6 month)		
Yes	1.00	
No	1.81 (1.10 – 2.99)	0.019
Iron (< EAR/AI)		
Breastfeeding (1month)		
EBFandPBF	1.00	
Mixed	0.83 (0.55 – 1.24)	0.363
Artificial	0.61 (0.30 – 1.23)	0.165
Breastfeeding (2month)		
EBFandPBF	1.00	
Mixed	0.97 (0.69 – 1.37)	0.863
Artificial	1.06 (0.65– 1.75)	0.809
Breastfeeding (4 month)		
EBFandPBF	1.00	
Mixed	0.88 (0.60 – 1.29)	0.522
Artificial	0.98 (0.61 – 1.58)	0.941
Complementary	1.13 (0.86 – 1.49)	0.380
Breastfeeding (6 month)		
Yes	1.00	
No	0.71 (0.49 – 1.05)	0.095

Poisson regression with robust variance; Adjustment for the variables: current breastfeeding, age and skin color of the child, mother's education, and family income.
Bold numbers indicate statistical significance (P <0.05).

complementary feeding to the end of the first year of life. The median intake of iron and vitamin A differed significantly between breastfeeding groups at all times evaluated.

Iron consumption was higher after six months in the group that was breastfed at1 month of life. This finding can be explained by the fact that children who are not breastfed tend to an early introduction of complementary feeding, with early access to iron source foods, meat for instance[29]. Nevertheless, it is important to consider the influence of confounders in the bivariate analysis, in which the medians between groups were simply compared. When the confounding variables for adjustment were included in the multivariate analysis, we found no difference in the prevalence of low iron intake from 6-12 months of life between breastfeeding patterns in the first 6 months.

Iron bioavailability in breast milk can be reduced by up to 80% when other foods are introduced[30]. Hence, the importance of exclusive breastfeeding in the first six months of life is em-

phasized with respect to the adequate intake of this micronutrient.

The early introduction of other milks may change the intestinal mucosal permeability in infants, triggering problems such as allergies, iron deficiency anemia, renal overload, and deficiency of vitamins, minerals, and essential fats (omega 3 and omega 6)[29,31,32]. Besides, breast milk can supply the child's physiological iron needs when exclusively supplied in the first six months, given its high bioavailability when compared with other types of milk. About 50% of iron ingested through breast milk is absorbed, whereas in bovine milk only 10% of the iron is consumed[30].

Finally, a number of limitations of this study need to be considered. The considerable follow -up losses are common in cohort studies. In this sense, a sample size was calculated, showing that there was enough sample to study the influence of breastfeeding on the worse food intake in children 6-12 months of life. Moreover, there was no differential bias when comparing the followed up children with those lost in the first six months. Complementary feeding data were obtained from only one 24-hour recall, which made it impossible to perform nutrient adjustment by intraindividual variability. However, we found that the feeding of children in this age group was monotonous, allowing the use of a single recall. In addition, other studies used only one food survey to assess nutrient intake in children[33,34]. Combining the children in exclusive and predominant breastfeeding was necessary because the children in predominant breastfeeding were less frequent. However, it is of note that the benefits of exclusive breastfeeding compared with the other patterns are unquestionable.

Nonetheless, the relevance of this study is emphasized by the investigation of the relationship between breastfeeding pattern and micronutrient intake in the first year of life, considering that this association is little studied. In clinical practice, the findings of this study reinforce the importance of breastfeeding in the formation of healthier eating habits and contribute to the prevention of diseases associated with poor diet in childhood. In other terms, in addition to the numerous benefits of breastfeeding for child health[3], this feeding practice positively influences food preferences in later stages[13].

In conclusion, more than one third of the children had below the recommendation vitamin A and iron intakes. Children who exclusively or predominantly breastfed in the first 6 months of life had a higher frequency of adequate vitamin A intake. Iron intake was lower among breastfed children, but the bioavailability of this nutrient in breast milk is higher. These findings reinforce the importance of public policies with the maternal and child group to encourage exclusive breastfeeding and the correct introduction of complementary feeding.

Collaborations

MA Silva: conceived and designed the analysis, collected the data, participated in data interpretation, wrote the paper. MM Soares: assisted in the conception and design of the analysis, collected the data, participated in data interpretation, wrote the paper. PCA Fonseca: assisted in the conception and design of the analysis, collected the data, participated in data interpretation, wrote the paper. SA Vieira: assisted in the conception and design of the analysis, collected the data, participated in data interpretation, wrote the paper. CA Carvalho: assisted in the conception and design of the analysis, collected the data, participated in data interpretation, wrote the paper. RM Amaral: assisted in the conception and design of the analysis, collected the data, participated in data interpretation, wrote the paper. SCC Franceschini: supervision of the study; wrote the paper. JF Novaes: supervision of the study, wrote thepaper.

Aknowledgements

The authors thank the Minas Gerais State Research Support Foundation - Fapemig.

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Article submitted 23/03/2017
Approved 24/04/2018
Final version submitted 26/04/2018