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Prevalence of iron-deficiency anemia in children aged less than 60 months: A population-based study from the state of *Minas Gerais*, Brazil

Prevalência de anemia ferropriva em crianças menores de 60 meses: estudo de base populacional no Estado de Minas Gerais, Brasil

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ABSTRACT

Objective

To identify the prevalence of iron-deficiency anemia in children aged less than 60 months and the conditioning factors in *Minas Gerais,* Brazil.

Methods

This cross-sectional study conducted from February 2007 to July 2008 in *Minas Gerais* included a random sample of 725 male and female children aged less than 60 months. A household survey was administered to the children's parents or guardians to collect socioeconomic, demographic, food security, and the child's anthropometric data. The hemoglobin level was determined by a portable hemoglobinometer. Anemia was considered present when hemoglobin levels were below 11.0 g/dL. Statistical analyses estimated the prevalence

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of anemia and its association with socioeconomic, demographic, and food security-related variables. The model was adjusted by multivariate logistic regression. The significance level was set at 5% ($p<0.05$).

Results

The prevalence of anemia was 37.4%. The greatest prevalence occurred in the age group 6 to 24 months (43.0%). The associated variables were being female (*PR*=1.43; $p<0.026$); age (*PR*=1.53; $p<0.024$); and not frequenting a daycare center (*PR*=2.41; $p<0.001$). In the multivariate regression model, the variables being female and not frequenting a daycare center remained in the model.

Conclusion

The present population-based study found that in *Minas Gerais*, one-third (37.5%) of the children aged less than 60 months have iron-deficiency anemia. The results show that not frequenting a daycare center and being female are risk factors for anemia.

Keywords: Anemia iron-deficiency. Food security. Prevalence. Risk factors.

RESUMO

Objetivo

Identificar a prevalência de anemia em crianças menores de 60 meses e seus fatores condicionantes, em Minas Gerais.

Métodos

Estudo transversal com amostra probabilística de 725 crianças menores de 60 meses de idade, de ambos os sexos, realizado entre fevereiro de 2007 e julho de 2008, em Minas Gerais. Por meio de inquérito domiciliar aplicado aos responsáveis pelas crianças, foram obtidas informações sobre as condições socioeconômicas, demográficas e situação de segurança alimentar, bem como obtidas as medidas antropométricas. A dosagem de hemoglobina foi analisada em hemoglobinômetro portátil, considerando-se como anemia valor <11,0 g/dL. A análise estatística estimou a prevalência da anemia e sua associação com condições socioeconômicas, demográficas e segurança alimentar. O modelo foi ajustado por regressão logística multivariada. Adotou-se p<0,05 como nível crítico para definir significância estatística.

Resultados

A prevalência de anemia foi de 37,4%. A maior prevalência ocorreu na faixa etária de 6 a 24 meses (43,0%). As variáveis associadas foram: sexo feminino (RP=1,43; p<0,026); idade (RP=1,53; p<0,024) e não frequentar creche (RP=2,41; p<0,001). No modelo de regressão multivariada, permaneceram as variáveis sexo feminino e não frequentar creche.

Conclusão

O presente estudo, de base populacional, mostrou que em Minas Gerais um terço das crianças (37,5%) com menos de 60 meses de idade apresentava anemia ferropriva. Os resultados revelaram que não frequentar creche e ser do sexo feminino configuram situações de risco à ocorrência de anemia.

Palavras-chave: *Anemia ferropriva. Segurança alimentar e nutricional. Prevalência. Fatores de risco.*

INTRODUCTION

Anemia caused by iron deficiency, iron-deficiency anemia, is the most important nutrition problem in the world[1]. Despite the considerable economic and scientific development seen in the last decades regarding anemia, its global prevalence decreased only marginally. Estimates of the World Health Organization (WHO) indicate that 24.8% of the world population, that is, almost one-fourth of the population, is anemic[2]. Iron-deficiency anemia is defined as a serum hemoglobin level below 11.0 g/dL. The highest prevalences are found in children younger than 5 years of age and pregnant women[1]. In developing countries, 47.4% of the children in the 0-4 years' age group are anemic[1].

Iron-deficiency anemia stems from an unbalance between the amount of bioavailable

iron absorbed from food and the body's requirement. It represents the final manifestation of iron deficiency, characterized by small red blood cells because of inadequate hemoglobin, significant reduction in the body's iron reserves, and low hematocrit[2]. Iron is involved in many metabolic and oxidation reactions and is essential for mitosis. Once the deficiency during childhood sets in and remains for a long time, the health consequences are severe. The following changes have been observed: late psychomotor development, difficulties in language acquisition, significant loss of cognition, greater susceptibility to infections, fatigue, and irritability[3].

In Brazil the National Survey of Child and Woman Demography and Health[4] identified a prevalence of anemia of 20.9% in children aged less than 59 months, and the highest prevalence was in children aged less than 24 months (24.1%) followed by children aged 24-59 months (19.5%). A study conducted in the state of *Pernambuco*[5] with urban and rural representativeness found a prevalence of 32.8% in children aged 6 to 59 months without a significant difference between areas. In another population-based study in an urban area of the municipality of *Criciúma* (SC) with children aged less than 36 months, the prevalence of anemia was 54.0% and according to the authors, the highest prevalence was found in the 12-18 month age group[6].

In *Minas Gerais* studies conducted in different municipalities found prevalences that varied from 26.0% in two-year-olds[7] to 60.8% in infants aged 6-12 months[8]. However, there is no population-based data for children aged less than 60 months. Hence, the objective of this study was to identify the prevalence of iron-deficiency anemia in this age group and the associated factors.

METHODS

This is a subproject of a wider study called "Health and nutritional status of women aged 15 to 49 years and children aged less than 60 months from *Minas Gerais*: prevalence of obesity, iron-deficiency anemia, food security, and their economic determinants". A descriptive cross-sectional study was conducted with a probabilistic sample of children aged less than 60 months and women aged 15 to 49 years by the Food and Nutrition Coordination of the State Department of *Minas Gerais*.

The state of *Minas Gerais* is located in the southeastern region of Brazil. It has a population of 20,593,366 inhabitants, of which 85.6% live in urban areas[9]. The mean *per capita* income in 2009 was R$773.41, ranking the state eleventh among Brazilian states[9].

The municipalities were chosen based on the decision to work with the same municipalities included in the "Project SB2000: A perspective for the consolidation of epidemiology in public oral health", a study done in 2000 by the Ministry of Health[10]. The said study followed the logic of stratification proposed by Roncalli *et al.*[10], dependent on population size. The 853 municipalities of *Minas Gerais* were stratified and their contribution to the total inhabitants of the state, calculated. Next the number of municipalities were selected randomly for each population stratum, that is, eight municipalities with up to 5,000 inhabitants were selected, representing 29.6%; five municipalities with 5,001 to 10,000 inhabitants were selected, representing 18.8%, and 14 municipalities with up to 10,000 inhabitants of a total of 27 municipalities.

Representative samples of women aged 15 to 49 years and children aged less than 60 months were calculated for the 27 municipalities. Since there are no representative population-based studies about iron-deficiency anemia for the state of *Minas Gerais*, we considered an expected prevalence of 50% for this morbidity for children aged less than 60 months with a significance level of 95%. The effect of the sampling plan was given by expressions published by Katz[11], resulting in a minimum sample of 600 children and 1,200 women. A design effect equal

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to 1.8 was used to make up for sample losses such that the maximum stipulated sample was of 1,000 children and 1,200 women, with an error margin smaller than 4%.

Next the number of *census* tracts in each municipality was systematically drawn, proportional to the rural and urban population, with a total of 200 *census* tracts. This number was then used to define the number of households *per* tract, that is, each municipality has a total number of *census* tracts (N) and a number to be sampled (n), so that the sampling factor is K=N/n, reaching a total of 10 households per sector. To get to the household, we first obtained from the Brazilian Institute of Geography and Statistics the *census* tract maps to number the blocks from left to right and the respective outlines (beginning at the left and continuing clockwise). After numbering the blocks in each *census* tract, the blocks were drawn, three blocks from each sector. In the field all households in the selected block were counted and numbered. From this total (N), we found the multiple value (K) to perform the systematic sampling: K=N/10, drawing a number between 1 and K to be the first sampled household. We add K to this first number to get the next household and so on until ten households were sampled. If a household had no children or women aged 15 to 49 years, the household right next to it was selected, always in a clockwise fashion. If a block did not have ten households, we would go to the second previously drawn block, and if necessary, up to the third also previously selected. The children eligible for the study were those in good general condition aged less than 60 months.

The data were collected from February 2007 to July 2008 using a questionnaire about food security and forms for recording information about the household, economic aspects, the child (frequenting a daycare center and having meals at the facility), anthropometry, and hemoglobin level. After presenting the study objectives and obtaining signed consent from the child's parents or guardians, the team supervisor interviewed them, and nursing/nutrition students performed the other procedures at the child's home. The entire field team was trained for the study. The socioeconomic data collected were: family income in Minimum Salaries (MS), education level of the family head (in years), number of rooms, and number of people in the household.

Food security was assessed by the *Escala Brasileira de Insegurança Alimentar* (EBIA, Brazilian Scale of Food Insecurity). EBIA is a subjective method for assessing how the families feel and react before the expectation of food (in)security, that is, before the risk of experiencing hunger[12]. It consists of a standardized questionnaire with 15 questions for the household's cook, measuring the concept of food security/food insecurity at different levels according to the interviewee's perception[13]. The scale allows the determination of the family's food security level by quantifying the total number of affirmative answers, that is, each affirmative answer receives a score of one. The scale score is given by adding the answer scores so it ranges from zero to fifteen points: zero (0): food security; 11-15 points: severe food insecurity.

The question regarding Exclusive Breastfeeding (EB) followed the recommendation of the Pan American Health Organization/World Health Organization (WHO): exclusive feeding with breast milk complemented with no other fluid or solid, except vitamins, minerals, or medications[14].

Weight was measured by a digital scale of the brand Kratos, model Linea, with capacity of 150 kg and accuracy of 0.1 kg. The children were weighed barefoot wearing minimal clothing. Children younger than 24 months were weighed naked by a scale coupled with a pediatric cradle, following the manufacturer's recommendation. Their length was measured by an anthropometer for children measuring 1.5 m and millimetric accuracy. Children aged more than 24 months were measured by a portable stadiometer of the brand *Altura Exata*, also with millimetric accuracy.

The anthropometric data were collected as recommended by Jellife[15]. Nutritional status was classified according to the child's weight-for-age and height-for-age in Z-scores, as proposed by the WHO[16]. The child's weight-for-age was classified as follows: -3 ≤Z-score <-2 as underweight for age; -2≤ Z-score ≤2 as normal weight for age; and 2 <Z-score ≤3 as overweight for age. The child's height-for-age was classified as follows: Z-score <-3 as severely stunted; -3≤ Z-score <-2 as stunted; and Z-score ≥-2 as adequate height.

The hemoglobin level was determined by drawing blood by skin puncture and analyzing it with a high precision portable photometer of the brand HemoCue AB AngelholmnSweden (Blood Hemoglobin Photometer). Anemia was defined as a hemoglobin level smaller than 11 g/dL, as recommended by the WHO[1].

In order to identify possible age-related risk factors for the occurrence of anemia, the sample was stratified into the following age groups: 0 to 6 months; 6 to 24 months; and 24 to 60 months.

The questionnaires were digitized and stored in the database Access 2008. Before the analyses, the database was verified for consistency and possible typing errors. In the case of inconsistencies (validation was done by Access), the original files were consulted for corrections. Nutritional status was assessed by the software Anthro, distributed by the WHO using WHO-2006's anthropometric standard.

The statistical analysis was performed by the program R. The global prevalence of iron-deficiency anemia was estimated according to socioeconomic variables, crude and adjusted prevalence *ratios*, and their respective confidence intervals. Confounding factors were controlled by adjusting the model by unconditional multivariate regression, making anemia the dependent variable.

The variables that presented statistical association with $p<0.20$ in univariate regression and some variables that the literature considered important risk factors for anemia, such as number of persons in household, breastfeeding, income, and education level, were selected for multivariate analysis to verify their independent effect on the study condition.

In multivariate analysis a complete model was composed, incorporating all variables previously selected and excluding those that were successively discarded by the initial model. In this

Table 1. Description of the sample according to socioeconomic, demographic, nutritional status, and living condition characteristics. *Minas Gerais* (2007).

Characteristic	N	%
Gender		
Male	350	48.3
Female	375	51.7
Age (months)		
Up to 6	104	14.3
>6,01 ≤24	228	31.4
>24,01	393	54.2
Scholarity		
Illiterate	21	2.9
Basic Education	370	51.1
High School	274	37.8
Undergraduation	60	8.3
Family income (minimum wage)		
<1,0	145	20.0
≥1,01 <2,0	273	37.7
≥2,01	307	42.3
Number of domicile rooms		
One	6	0.8
Two	25	3.4
Three	81	11.2
More than three	613	84.6
Number of dweller		
Two	11	1.5
Three	169	23.3
Four	231	31.9
Five or more	314	43,4
Nutrional status: *height/age*		
<-3SZ	24	3.3
≥-3 e <-2SZ	42	5.7
≥-2SZ	659	90.8
Weight/age		
≥-3 e <-2SZ	35	4.8
≥-2 e <2SZ	649	89.5
>2SZ e ≤3SZ	41	5.6

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process the variables whose prevalence ratios and confidence intervals did not change significantly were maintained until a final model was obtained. This model was assessed by Prevalence *Ratio* (*PR*) and a Confidence Interval of 95%.

The study followed the regular research norms involving human beings, Resolution nº 196/96 from the National Health Council, and was authorized by the Research Ethics Committee of *Hospital Eduardo de Menezes* of the Hospital Foundation of the State of *Minas Gerais* under Protocol number 109/07.

The children with hemoglobin level below 11 g/dL were sent, along with their record, to the health unit nearest to their home for treatment.

RESULTS

A total of 725 children were assessed, representing a greater number than the number of children needed for the minimum sample size for the 27 municipalities selected for the study. The losses were due to refusal to participate in the study. The mean age was 27.5 months

Table 2. Prevalence of anemia in children aged less than 60 months according to demographic and socioeconomic variables. *Minas Gerais* (2007).

Variables	Anemia				*p*-value	*PR*	95%CI
	Yes		No				
	n	%	n	%			
Gender							
Male	117	33.4	233	66.6	0.038*	1.00	
Female	154	41.1	221	58.9		1.38	1.02 - 1.87
Total	271	37.4	454	62.6			
Age (months)							
Up to 6	44	42.3	60	57.7	0.024	1.49	0.96 - 2.32
>6,01 ≤24	98	43.0	130	57.0		1.53	1.09 - 2.15
>24,01	129	32.9	263	67.1			
Household scholarity responsible							
Illiterate	11	52.4	10	47.6	0.437	2.04	0.74 - 5.59
Basic Education complete/incomplete	142	38.4	228	61.6		1.15	0.65 - 2.04
High School	97	35.4	177	64.6		1.01	0.56 - 1.82
Undergraduation	21	35.0	39	65.0		1.00	
Family income (minimum wage)							
<1,0	55	37.9	90	62.1	0.355	1.15	0.76 - 1.74
≥1,1 <2,0	110	40.3	163	59.7		1.28	0.91 - 1.79
≥2,1	106	34.5	201	65.5		1.00	
Number of domicile rooms							
One	4	66.7	2	33.3	0.560	3.40	0.61 - 18.71
Two	10	40.0	15	60.0		1.13	1.50 - 2.26
Three	30	37.0	51	63.0		1.00	0.61 - 1.61
More than three	227	37.0	386	63.0		1.00	
Number of dweller							
Two	3	27.3	8	72.7	0.693	1.00	
Three	58	34.3	111	65.7		1.39	0.35 - 5.45
Four	89	38.5	142	61.5		1.67	0.43 - 6.46
Five or more	121	38.5	193	61.5		1.67	0.43 - 6.42

Note: *Fischer's exact test.

PR: Prevalence *Ratio*; 95%CI: 95% Confidence Interval.

(Standard Deviation-SD=17.3 months), and the percentage of males was slightly smaller (48.3%) (Table 1).

The prevalence of anemia in the total sample was 37.4%. The highest prevalence was 43.0% in the age group 6-24 months (Table 2). Some (4.8%) children were underweight for their age according to the weight-for-age indicator, and 5.7% were overweight. According to the weight-for-height indicator, 7.9% of the children were overweight. The nutritional indicators were not associated with anemia regardless of situation (Table 3).

The final model was constructed by selecting the variables statistically (p<0.05) associated with anemia, namely gender, age group, and not frequenting a daycare center, and the variables with p<0.20 (food security and weight-for-height).

Table 4 shows the variables that remained in the adjusted multivariate regression model. After adjustment for the variables of the same level, age lost its statistical significance, and being female and not frequenting a daycare center remained associated with anemia.

DISCUSSION

The present population-based study showed that more than one third (37.4%) of the children under 60 months of age from the state of *Minas Gerais* are anemic. Although deficiency of other nutrients may determine anemia, iron-deficiency is by far the most common cause in

Table 3. Prevalence of anemia in children aged less than 60 months according to frequenting a daycare center status, breastfeeding status, food security level, and nutritional status. *Minas Gerais* (2007).

Variables	Anemia				*p*-value	*PR*	95%CI
	Yes		No				
	n	%	n	%			
Scholl/daycare center							
Yes	34	22.7	116	77.3	<0.001*	1.00	-
No	237	41.3	338	58.8		2.39	1.57 - 3.62
Meals at home?							
Yes	32	22.4	111	77.6	<0.001*	1.00	-
No	239	41.1	343	58.9		2.41	1.57 - 3.70
Exclusive breastfeeding							
Yes	237	38.1	385	61.9	0.323	0.80	0.51 - 1.24
No	34	33.0	69	67		1.00	-
Food security							
Security	112	34.4	214	65.6	0.167	1.00	-
Severe insecurity	24	47.1	27	52.9		1.69	0.93 - 3.08
Height/age							
<-3 SZ	10	41.7	14	58.3	0.901	1.20	0.52 - 2.75
≥-3 e <-2	16	38.1	26	61.9		1.04	0.54 - 1.97
≥-2 SZ	245	37.2	414	62.8		1.00	-
Weight/age							
≥-3 e <-2 SZ	11	31.4	24	68.6	0.675	1.00	-
≥-2 SZ e <2 SZ	246	37.9	403	62.1		1.33	0.64 - 2.76
>+2 SZ e ≤3 SZ	14	34.1	27	65.9		1.13	0.43 - 2.96

Note: *Fischer's exact test.

PR: Prevalence *Ratio*; 95%CI: 95% Confidence Interval.

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Table 4. Prevalence *ratio* of anemia adjusted for multivariate regression model. *Minas Gerais* (2007).

Characteristics	Adjusted Prevalence *Ratio* (95%CI)	*p*-value
Gender		
Male	1.00	0.026
Female	1.43 (1.03-1.90)	
Scholl/daycare center		
Yes	1.00	<0.001
No	2.41 (1.16-3.66)	

Note: 95%CI: 95% Confidence Interval.

regions where the prevalence of anemia is high[17]. Therefore, the terms anemia and iron-deficiency anemia are used interchangeably in public health; according to the WHO, anemia is synonymous with iron-deficiency anemia[18]. With parameters defined by the WHO, this prevalence represents a moderate public health problem in the state[19].

Studies in different Brazilian municipalities found similar results, with anemia being significantly associated with more individuals per household and worse education level of the family head[20,21]. However, in this study, these variables were not associated with anemia. The study concludes that frequenting a daycare center or similar institutions in *Minas Gerais* during the study age (first 60 months of life) was protective because the prevalence of anemia in children who did not frequent a daycare center (41.3%) was almost double of those who did (22.7%) and had meals in schools.

Daycare centers are institutions that care for children aged zero to three years and preschoolers aged four to six years. They are an option for the population given the new socioeconomic reality of the last decades. Since children remain in a daycare center from eight to ten hours a day, this facility has an important role in the child's formation, improving their health since in addition to education, the children receive basic health care and quality meals that satisfy their nutritional needs[22]. Studies conducted in the state of *Paraíba* and in the municipality of *Viçosa* (MG), with children aged 24 to 72 months who frequent daycare centers found a relatively low prevalence of anemia: 11.2%[23] and 15.4%[24], respectively.

The prevalence of anemia among children who are exclusively breastfed was of 38.1%. Important for preventing childhood anemia, breastfeeding for more than six months increases the risk of anemia since 90.0% of the iron requirement of the child comes from complementary foods[25]. A recent study on exclusive breastfeeding and iron-deficiency anemia found that 26.1% of the breastfed children were iron deficient, and 23.9% had iron-deficiency anemia[26]. Improving the iron reserves of the mother is an alternative to improve the iron reserves of breastfed children. Iron reserves at birth are smaller when the mother's reserves are low, reflecting the limited ability of the fetus to acquire iron. A study done in Indonesia with breastfed children aged four to six months found a prevalence of anemia of 37.0% (Hb <10.0 g/dL), having as associated factor the mother's hemoglobin level[27-29].

Among children aged 6 to 24 months, the prevalence of anemia was 43%, and the association was statistically significant.

Above six months, the high prevalence can be explained by the depletion of the body's iron reserves acquired during intrauterine life along with the higher nutritional requirement due to faster growth. Together with a delayed introduction of high-iron foods, this constitutes a scenario that facilitates the development of anemia in this life stage[30].

Qualitative or quantitative deficiency of dietary iron stemming from low iron intake or low

bioavailability in foods has been pointed out as the most common cause of anemia[31]. In this perspective, we assessed exposure to food insecurity at the household, a hypothesis in the scenario of social inequalities that can explain the high prevalence of iron-deficiency anemia. The result, regardless of the statistically insignificant association, indicated that a slight improvement in the food insecurity situation of the family decreased the risk of anemia.

The concept of Food and Nutrition Security (FNS) in Article 3 of the Food and Nutrition Security Law is defined as:

> The realization of everyone's right to regular and permanent access to quality foods, in adequate amounts, without compromising access to other essential needs, based on food practices that promote health, respect cultural diversity, and that are socially, economically, and environmentally sustainable (National Food Security Council, Law nº 11.346/15/09/2006)[32].

Food security is first and foremost a right to life and being exposed to an inappropriate diet or not having the means to acquire an appropriate diet is an affront and a violation of an established right. If on the one hand proper food is an individual right and ensuring FNS a state obligation, on the other hand identifying food insecurity of population groups in different locations is imperative, since it allows the planning of actions that materialize the condition for citizenship[33,34].

The situation of food security, that is, a situation in which there is no food restriction of any kind in the household, was identified in 44.8% of the households[13,34]. However, children living in these households presented a prevalence of anemia of 34.5%.

Severe food insecurity, a situation in which food restriction is such that the children in the household also experience hunger, was identified in 7.0% of the study households, with a prevalence of anemia of 47.1%. In this scenario people live in a state of restriction, resulting from inadequate economic resources to allow a minimum level of consumption[12].

The results regarding the food security situation, even though not statistically associated with anemia, show that anemia has disseminated throughout all social classes and in families from different income strata. However, the prevalence tends to be highest in the most socioeconomically vulnerable groups, as seen in a study conducted in a municipality located in the Brazilian Northeast region[12].

Guarantee of income availability is unarguably one of the determinants of the level of food and nutrition security. However, finding that iron-deficiency anemia was present in 34.5% of the food-secure children evidences the importance of studying the singularities of its social distribution more thoroughly. As stated by Szarfarc[35]: "It is essential to know exactly how socioeconomic condition impacts dietary iron and the mechanisms in which this nutrient determines its organic reserves and consequently, the blood hemoglobin level" (p.6).

In this sense, the results provide consistent data for new studies since desirable information, such as identification of the social determinants of anemia in children under 60 months of age, was not found. The study factors related to the outcome indicate that certain interventions outside of the health sector are possible, such as in the field of food security. Regarding the health area, the performance of studies at regular intervals with the same age group allows the creation of temporal series that help to discover effective interventions for the prevention of iron-deficiency anemia in this group. The present study can be a first step in this direction.

CONCLUSION

The present study evidenced the high prevalence of a nutritional deficiency in children aged less than 60 months, which can markedly

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and perversely compromise the child's development. The study revealed a risky scenario that assumes different forms regarding iron-deficiency anemia: age (children younger than two years old), gender (being female), and not frequenting a daycare center are important factors that should be considered during these children's lives.

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CONTRIBUTIONS

MBMC LISBÔA conceived and designed the study, collected data, performed the statistical analyses, interpreted the results, and wrote the manuscript. EO OLIVEIRA performed the statistical analyses and interpreted the results. JA LAMOUNIER J reviewed the manuscript. CAM SILVA performed the statistical analyses, interpreted the results, and reviewed the manuscript. RN FREITAS interpreted the results and reviewed the manuscript.

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