

Food and nutrition insecurity indicators associated with iron deficiency anemia in Brazilian children: a systematic review

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Abstract *This study aimed to review food and nutrition insecurity indicators associated with iron deficiency anemia in Brazilian children below 5 years. We searched in electronic databases (SciELO, Lilacs, and Medline) and selected studies by titles, abstracts and full-text reading. Of the 1,023 studies analyzed, 11 fit the inclusion criteria. The results of the studies evidenced that iron deficiency anemia in Brazilian children was associated with sociodemographic and health indicators (male, age below 24 months, children of adolescent mothers, respiratory infections, diarrhea, low maternal schooling, parents' working conditions, nursery time, lack of basic sanitation, maternal anemia, lack of ferrous sulfate use by the mother and/or child and late onset of prenatal care), nutritional indicators (low birth weight, diet characteristics, such as the habit of milk consumption close to meals, low exclusive and full breastfeeding time) and economic indicators (low per capita income). The food and nutrition insecurity analyzed in this study from the perspective of different indicators is associated with iron deficiency anemia in children under 5 years in Brazil.*

Key words *Iron deficiency anemia, Iron deficiency, Food and nutrition security, Children*

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Introduction

Micronutrient deficiency is an important public health problem, especially in developing countries. According to the World Health Organization (WHO), approximately 2 billion people worldwide suffer from hidden hunger, which is the subclinical deficiency of micronutrients, and the main ones are vitamin A, iron, zinc and iodine¹.

Iron deficiency is a three-stage process that affects all cells of the human body. The first stage is iron stock depletion, followed by iron-deficient erythropoiesis and then, ultimately, iron deficiency anemia, characterized by reduced hemoglobin levels. Iron deficiency and iron deficiency anemia result from imbalanced amount of bioavailable iron absorbed in the diet and the body's need for this mineral².

Iron deficiency anemia is a nutritional disorder that compromises the immune system and impairs children's growth and development³. The children's public is a group vulnerable to iron deficiency due to the increased demand of this mineral under the intense growth speed. In addition, some negative childhood dietary factors may step up this vulnerability, such as insufficient iron-source food consumption (beef, liver, chicken, fish and dark green vegetables)^{2,3} and intake of cow and goat milk in the first six months of life, which, in addition to low iron content, may cause gastrointestinal bleeding and lead to fecal blood loss⁴.

Anemia affects approximately 1.62 million individuals worldwide, and the occurrence due to iron deficiency is 2.5 times more likely^{5,6}. In Brazil, according to data from the National Demography and Women and Child Health Survey⁷, the prevalence of anemia in children under the age of 5 was 20.9%, with highest prevalence observed in the Southeast and Northeast regions of the country (22.6% and 25.5%, respectively).

The Food and Nutrition Security (FNS) refers to ensuring access to adequate and healthy food. It is a multidimensional concept that encompasses the field of production, availability and access to food, adequate health conditions, education, housing and basic sanitation⁸. Thus, indicators of multiple vulnerabilities related to access, consumption and biological use of food, social, economic and nutritional status conditions are adopted to characterize situations of violation of this right, that is, food and nutritional insecurity⁸.

Some indicators, such as low per capita household income, low maternal schooling, higher

number of children, high density of inhabitants per room, poor access to public services, such as basic sanitation and electricity, quantitatively and qualitatively inadequate food consumption, among others, evidence situations of food and nutritional insecurity that predispose to the risk of developing deficiency diseases, including iron deficiency anemia^{9,10}.

While iron deficiency anemia is a public health problem democratically distributed among different socioeconomic classes, situations that characterize a food and nutritional insecurity situation may favor and contribute to the onset of this disease⁹.

In light of the above, this paper aimed to review food and nutritional insecurity indicators associated with iron deficiency anemia in Brazilian children under 5 years of age.

Methods

This paper was elaborated following a systematic search in electronic databases SciELO, Lilacs and Medline. We included studies published in the last 11 years starting in 2004, when iron and folic acid compound fortification started to be implemented to meet one of the objectives of the National Food and Nutrition Security Plan, which refers to the prevention of nutritional deficiencies¹¹. Keywords used were breastfeeding, nutritional indicators, iron deficiency, hidden hunger and maternal anemia in both Portuguese and English equivalents.

This systematic review included original papers conducted in Brazil that associated iron deficiency anemia in Brazilian children under the age of five with possible food and nutritional insecurity indicators, categorized as: economic, nutritional, sociodemographic and health. Review papers, monographs, dissertations, theses, book chapters and studies with children from other countries were excluded.

Papers were systematically reviewed and, initially, two authors participated in the analysis of titles and abstracts. Any disagreement between the two evaluators ensued the participation of a third author, who analyzed the papers.

For the preparation of the systematic review, we first searched for keywords in the databases previously described and identified 1,023 studies published in the period of interest. The next step consisted of selecting and reviewing works, evaluating the titles first, in which 972 studies were excluded, of which 569 did not address the topic

of this review, 81 were duplicated studies and 322 were conducted on a non-Brazilian population.

After reading abstracts of the remaining 51 studies, 31 were excluded because they did not analyze the association with food and nutritional insecurity indicators. A total of 20 papers were fully analyzed, of which 9 were excluded as they included children older than 5 years. Thus, 11 studies fit the inclusion criteria and were adopted in this systematic review (Figure 1).

Results

The 11 selected studies reflect the relationship between food and nutritional insecurity indicators with iron deficiency anemia, and in all of them iron deficiency anemia was associated with some sociodemographic and health indicator; association with economic indicators was observed in four, and seven were associated with nutritional indicators.

The sociodemographic and health indicators described by studies, which were associated ($p < 0.05$) with iron deficiency anemia were: age less than 24 months¹²⁻¹⁶, maternal age less than 20 years^{17,18}, male children^{17,19}, number of residents at home^{2,15,20}, low maternal schooling^{13,15,20}, geographical area¹³, no home ownership¹⁹, respiratory infections and diarrhea^{2,19}, parental work conditions²¹, day-care time², lack of basic sanitation^{2,15} and maternal anemia¹⁹ (Chart 1).

Regarding economic indicators associated with iron deficiency anemia, in children under the age of five, low per capita income was unanimous among studies^{17,20,21} (Chart 1).

As to nutritional indicators, there is a lack of or low total breastfeeding^{17,20,21} and exclusive breastfeeding¹⁸ time, low birth weight^{17,19}, early introduction of food²⁰, milk intake close to meals^{13,20}, non-use of ferrous sulfate by mother and/or child and late onset of prenatal care²¹ (Chart 1).

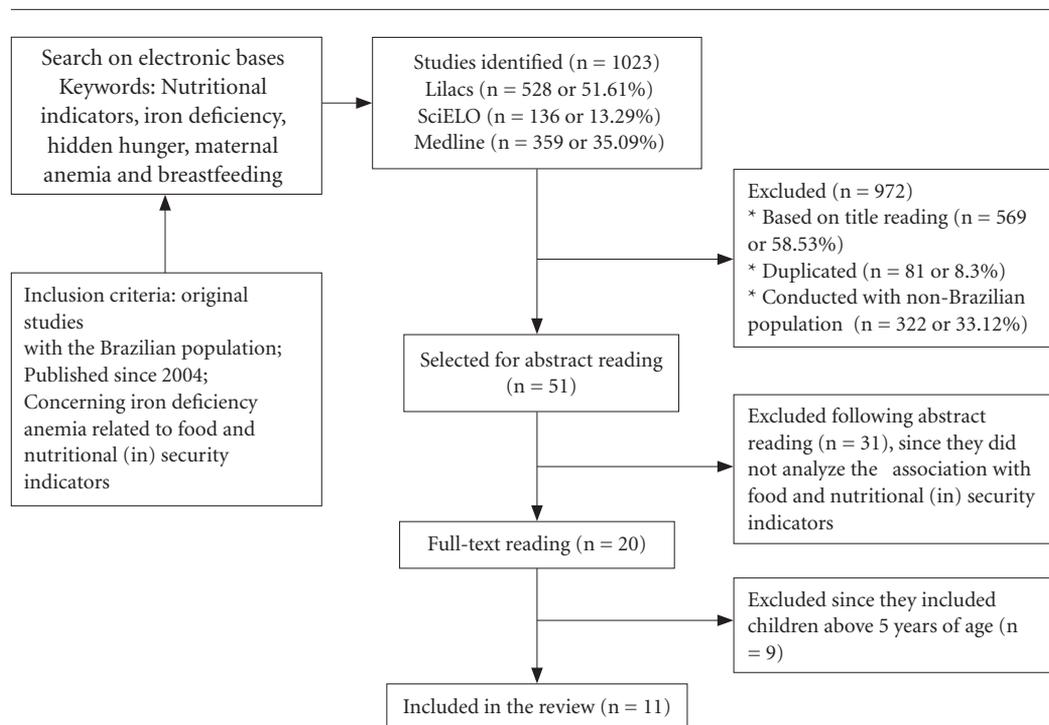


Figure 1. Stages of the systematic review elaboration.

Chart 1. Summary of the studies concerning indicators of food and nutritional insecurity associated with iron deficiency anemia in children under 5 years of age.

References	Studies Methods				Results	
	Title	Type of study	Location	Evaluation of iron nutritional status	Anemia	Food and nutritional insecurity indicators
Neves et al., 2005 ¹²	Prevalence and factors associated with iron deficiency in infants (n = 365)	Cross-sectional	Belém-Pará	Hemoglobin Ferritin	Prevalence of iron deficiency anemia and iron deficiency: 55.1% and 15.3% respectively	Iron deficiency anemia and iron deficiency had an association (p < 0.05) with sociodemographic (infants 6 to 24 months) and economic (per capita income less than ½ minimum wage) indicators.
Spinelli et al., 2005 ¹⁷	Risk factors for anemia in children (n = 2,715)	Cross-sectional	States of Paraná, Rio Grande do Sul, Minas Gerais, Rio de Janeiro, São Paulo and Mato Grosso (Multicenter).	Hemoglobin	Prevalence of anemia: 65.45%.	Anemia was associated (p < 0.05) with sociodemographic (maternal age below 20 years, male gender) and nutritional (lack of breastfeeding or mixed feeding, birth weight < 2500g) indicators.
Oliveira et al., 2006 ¹³	Hemoglobin concentration and anemia in children: socioeconomic and food consumption factors (n = 746)	Cross-sectional	Recife-Pernambuco	Hemoglobin	Prevalence of anemia: 40.6%.	Anemia was associated (p < 0.05) with sociodemographic (age of the child, geographic area, maternal schooling), economic (per capita income of less than ½ minimum wage) and nutritional (intake of cow milk in the diet) indicators.

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Discussion

Iron deficiency anemia is one of the greatest public health problems in the world, and stands out as the main nutritional deficiency due to negative health effects. Children under the age of five are among the vulnerable groups, due to increased demands for growth and development, typical of this stage^{16,17}. Among the main consequences of iron deficiency anemia are impaired psychomotor development and cognitive function and increased susceptibility to infections^{7,16,17}.

Regarding the sociodemographic factors quoted by studies of this review, we highlight the age of less than 24 months, the high number of residents in the household and maternal schooling^{2,12-15,20}. In addition to these sociodemographic factors, other studies^{9,22} found an association of iron deficiency anemia with lower age and maternal schooling.

Situations of multiple vulnerabilities, such as the high number of residents in the household, lower level of maternal schooling, lower per capita monthly income and lower purchasing power

Chart 1. continuation

References	Studies Methods				Results	
	Title	Type of study	Location	Evaluation of iron nutritional status	Anemia	Food and nutritional insecurity indicators
Netto et al., 2006 ²⁰	Prevalence and factors associated with anemia and iron deficiency in children (n = 101)	Cross-sectional	Viçosa-Minas Gerais	Hemoglobin Ferritin	Prevalence of anemia and iron deficiency: 30.1% and 38.4%, respectively.	The sociodemographic (number of residents at the same address, maternal schooling) and nutritional (age of introduction of juices and / or fruits, and total breastfeeding time, milk consumption close to meals) indicators were associated (p < 0.05) with low levels of hemoglobin and iron deficiency.
Vieira et al., 2007 ¹⁴	Evaluation of nutritional status of iron and anemia in children (n = 162)	Cross-sectional	Recife-Pernambuco	Hemoglobin Ferritin	Prevalence of anemia and iron deficiency: 55.6% and 30.8%, respectively.	Anemia and iron deficiency were associated (p < 0.05) with sociodemographic indicators (age less than 24 months).
Konstantyner et al., 2009 ¹⁸	Isolated and aggregated risks of anemia in children attending nursery in kindergartens (n = 482).	Cross-sectional	Public nurseries of São Paulo	Hemoglobin	Prevalence of anemia: 43.6%.	Iron deficiency anemia was associated (p = < 0.05) with sociodemographic (lower maternal age), economic (per capita income of less than ½ minimum wage) and nutritional (exclusive breastfeeding of less than 2 months) indicators.
Netto et al., 2011 ²¹	Factors associated with anemia in term infants without low birth weight (n = 104)	Cross-sectional	Viçosa-Minas Gerais	Hemoglobin Ferritin	Prevalence of anemia: 26%	Anemia of infants was associated (p < 0.05) with nutritional (non-use of ferrous compound in the postpartum period by the mother or the child, late onset of prenatal care, predominant breastfeeding) and sociodemographic (parents' work conditions) indicators.

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influence and hinder the conditions of access to adequate and healthy food, which may favor the onset of nutritional deficiencies, such as iron deficiency anemia²³.

The association of iron deficiency anemia with the lowest maternal age, especially in relation to adolescent pregnant women can be attributed to lower child care experience (mother-child bonding), which reflects, in most cases, the lack of knowledge or appropriate guidance

during prenatal care, which in some situations is not even adequately performed^{9,22}.

The low per capita monetary income was the economic indicator most cited by studies associated with anemia^{12,13,18}. Besides providing access to food, income is related to housing and basic sanitation conditions, important for the biological use of food nutrients, and thus low income situations are directly related to two important determinants of FNS – body access and utiliza-

Chart 1. continuation

References	Studies Methods				Results	
	Title	Type of study	Location	Evaluation of iron nutritional status	Anemia	Food and nutritional insecurity indicators
Rodrigues et al., 2011 ²	Iron deficiency, prevalence of anemia and factors associated in children (n = 256)	Cross-sectional	Cascavel-Paraná	Hemoglobin, mean corpuscular volume, serum iron and eosinophils.	Anemia prevalence was 29.7%, with 77.3% of low iron concentration.	Anemia and iron deficiency were associated ($p < 0.05$) with sociodemographic indicators (frequent diseases in the household, living conditions, nursery time, number of residents in the household and lack of basic sanitation).
Leal et al., 2011 ¹⁵	Prevalence of anemia and factors associated in children (n = 1,403)	Cross-sectional	Recife-Pernambuco	Hemoglobin	Prevalence of anemia: 32.8%	Sociodemographic indicators (maternal schooling and anemia, number of children in the same household, water treatment, children's age) were association ($p < 0.05$) with anemia.
Castro et al., 2011 ¹⁹	Anemia e iron deficiency em preschoolers of the Amazon region (n = 624)	Cross-sectional	Acre-Amazon region	Hemoglobin Ferritin and soluble plasma transferrin receptor	Prevalence of anemia, iron deficiency anemia and iron deficiency was 30.6%, 20.9% and 43.5% respectively.	Anemia, iron deficiency anemia and iron deficiency were associated ($p < 0.05$) with sociodemographic (male gender, no home ownership, respiratory infections and diarrhea) and nutritional (low birth weight) indicators.
Lisboa et al., 2015 ¹⁶	Prevalence of iron deficiency anemia in children (n = 725)	Cross-sectional	Minas-Gerais	Hemoglobin	Prevalence of anemia: 37.4%, children from 6 to 24 months: 43%.	Anemia was associated ($p < 0.05$) with sociodemographic indicators (not attending nursery, infants aged 6-24 months).

tion of food – which may lead to situations of insecurity, especially in cases where low income is found in conjunction with other indicators mentioned in this review.

Regarding the observed association of anemia with the age of less than 24 months, it is believed that the risk of developing iron deficiency anemia in this age group is due to the accelerated growth characteristic of this stage, along with nutritional indicators, such as the transition diet, which is usually composed of food with low iron bioavailability, low prevalence of breastfeeding and respiratory infections and diarrhea^{9,12,24}.

Food and nutritional insecurity nutritional indicators shown in this review were summarized in birth conditions (low birth weight), breastfeeding and early introduction of complementary foods.

In a national study regarding factors associated with anemia in Brazilian children aged 6 to 12 months, authors described a prevalence of anemia of 65.45%, and its association ($p < 0.05$) with low birth weight and prematurity¹². One of the possible explanations for this association was the low iron reserves at birth, mainly due to prematurity and low weight, and the higher demand of this mineral for the growth process²¹.

In a study on anemia and iron deficiency in preschoolers in the Brazilian Western Amazon, authors observed a prevalence of anemia, iron deficiency anemia and iron deficiency of 30.6%, 20.9% and 43.5%, respectively, and association ($p < 0.05$) with low birth weight and male gender¹⁹. The association between iron deficiency anemia and male gender is related to greater weight gain, increased erythropoiesis activity in

fetal life, lower reserves, greater intestinal losses and lower iron absorption observed in boys in relation to girls²⁵.

Studies^{20,26-29} related to factors associated with anemia and iron deficiency in children showed association ($p < 0.05$) with other nutritional indicators, such as age of introduction of juices and/or fruits, milk consumption close to meals and total breastfeeding time, and the highest prevalence was found in children younger than 24 months of age. We must emphasize that it is difficult to establish critical hemoglobin values as a cutoff point in children younger than 6 months of life due to the rapid changes in concentration of this biochemical indicator in this life stage³⁰.

The consumption of fluid cow milk was one of the main determinants of anemia in the first year of life; cow milk's casein and whey proteins, which are the protein fraction of most milk formulas and industrialized infant foods have a negative influence on iron absorption, which are aggravated by increased nutritional requirements as a result of children's accelerated growth²⁴. Milk and its derivatives, such as yogurt and cheese have calcium and, when consumed during or near meals, inhibit iron absorption³¹.

It is believed that the situation of food and nutritional insecurity analyzed under the perspective of different indicators that encompass the multidetermination involved with the Brazilian concept of FNS is influenced by inequalities related to the exclusionary social and economic system³², and poverty and social inequities are determinants of this phenomenon^{33,34}.

Most of the studies analyzed in this systematic review that evaluated food and nutritional insecurity indicators associated with iron deficiency anemia in Brazilian children under five years of age are cross-sectional observational studies.

This type of epidemiological design hinders the establishment of causal relationships, which is a limitation of this systematic review and highlights the importance of conducting longitudinal studies with determinants of iron deficiency anemia in Brazilian children.

Conclusion

Analyzed from the perspective of different indicators, food and nutritional insecurity is related to iron deficiency anemia in Brazilian children under 5 years of age. The insecurity conditions evaluated according to the indicators mentioned above indicate the need for investments to improve living conditions, as well as the need to promote breastfeeding and appropriate introduction of complementary feeding.

This review evidenced that iron deficiency anemia was associated with sociodemographic and health (male gender, age less than 24 months, no nursery attendance, children of adolescent mothers, high number of residents in the same household, respiratory infections, diarrhea, low level of maternal schooling), nutritional (low birth weight, dietary characteristics, "habit of ingesting milk close to meal times" and early introduction of complementary food) and economic (low per capita income) indicators that reflect the social determination of this deficiency.

In order to ensure FNS, it is necessary to adopt intersectoral measures that focus on the multiple determinants involved in this right, especially those related to access to adequate and healthy food and food biological utilization, which are directly related to micronutrient deficiencies that affect a significant proportion of the population, especially children.

Collaborations

HP André worked on the design, final writing and review; N Sperandio, RL Siqueira, SCC Franceschini and SE Priore worked on the final writing and critical review.

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Article submitted 14/03/2016
 Approved 11/07/2016
 Final version submitted 13/07/2016