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Article *in* Public Health Nutrition · November 2020

DOI: 10.1017/S1368980020004711

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Public Health Nutrition: 24(15), 4888–4898 doi:10.1017/S1368980020004711

Factors associated with childhood anaemia in Afro-descendant communities in Alagoas, Brazil

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Submitted 28 June 2020: Final revision received 3 November 2020: Accepted 12 November 2020: First published online 19 November 2020

Abstract

Objective: To investigate factors associated with anaemia in preschool children.
Design: A home survey was conducted in 2018. Anaemia in children (capillary blood Hb level < 110 g/l) was the outcome, and socio-economic, demographic and health factors of the mother and child were the independent variables. The measure of association was the prevalence ratio, and its 95 % CI was calculated using Poisson's regression with robust variance and hierarchical selection of independent variables.
Setting: Afro-descendants communities living in the state of Alagoas, northeast Brazil.
Participants: Children aged 6–59 months and their mothers (*n* 428 pairs).
Results: The prevalence of child anaemia was 38·1 % (95 % CI 33·5, 42·7). The associated factors with child anaemia were male sex, age < 24 months, larger number of residents at home (> 4), relatively taller mothers (highest tertile) and higher *z*-score of BMI for age, after further adjustment for wealth index, vitamin A supplementation in the past 6 months and clinical visit in the last 30 d.
Conclusions: The high prevalence of anaemia observed reveals a relevant public health problem amongst children under five from the quilombola communities of Alagoas. Considering the damage caused to health and multiplicity of risk factors associated with anaemia, the adoption of intersectoral strategies that act on modifiable risk factors and increase vigilance concerning those that are not modifiable becomes urgent.

Keywords
Anaemia
Risk factors
Child health
Afro-descendants
Health Status
Brazil

Anaemia is characterised by a reduction in Hb level and/or number of erythrocytes, a condition that leads to a decrease in oxygen transport, with consequent tissue hypoxia(1). Globally, it affects approximately one-third of the population(2), mainly pregnant women and children aged < 60 months(3,4). In children, anaemia can cause growth and development impairments, promote cognitive and immunological capacity reduction and contribute to increased morbidity and mortality(5,6). Thus, anaemia has harmful consequences to human health and social and economic development in low-, middle- and high-income countries(2,4,6).

At the end of the last century, anaemia was considered a democratic disease, as it affected individuals from all countries and socio-economic strata, unlike wasting, which predominantly occurred in scenarios characterised by hunger and poverty(7). Nevertheless, it was recognised that this pathology was more frequently observed in populations that lived in less developed regions of the world.

The WHO has adopted a plan of targets to be achieved by 2025, focusing on increasing the nutritional status of mothers and children, intending to reduce anaemia by 50 % in women of reproductive age. However, the WHO proposes criteria based on prevalence levels that allow

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public policy managers to classify the relevance of the problem in the public health, including actions for child anaemia prevention and control[8].

In Brazil, actions to prevent anaemia have been developed for some time. In 2004, excited with the decision of the Ministry of Health to implement a national programme, Filho[7] declared that with the list of proposed measures, it was possible to draw a promising perspective in which anaemia control would finally be achieved at levels acceptable by WHO (< 5·0 %). In the following year, the National Program of Iron Supplementation was implemented, with actions of prophylactic Fe supplementation, Fe fortification in maize and wheat flours and development of education and health promotion activities[9]. Although many studies have found reductions concerning initial levels, anaemia is still a public health problem in Brazil[10].

Anaemia has several aetiologies; however, Fe deficiency is its main determinant. Generally, approximately 50 % of anaemia cases are caused by Fe deficiency, but this proportion varies according to the population groups and in different areas, depending on local conditions. Therefore, any strategy implemented to address anaemia must be adapted to the local reality, considering its main determinants[6].

A meta-analysis conducted in 2010 and updated in 2020[10,11] estimated the prevalence of anaemia in Brazilian children according to the origin of the primary study samples: population-based, day-care centres, health services and populations in social inequities. The analysis of these two studies allows us to observe that (a) reductions have occurred, but the situation remains moderate to severe in all scenarios; (b) there is a considerable difference in the risk of anaemia according to the context and living conditions and (c) the prevalence of anaemia. It remains a severe public health problem (≥ 40·0 %) among children who live in communities that are subject to greater social vulnerability. Among these, indigenous peoples and quilombola communities stand out in Brazil.

Alagoas is a state located in the northeast region of Brazil, characterised by the worst socio-economic indicators[12,13], a condition that predisposes a higher risk of anaemia for its population. A study conducted on children from Alagoas revealed that the prevalence of this condition was 45·1 % in 2005, which declined to 27·4 % in 2015[14]. In this state, there are currently sixty-eighty remaining communities of the quilombos, which are constituted by descendants of African slaves. This population is subjected to greater social vulnerability, resulting from the historical process of exclusion and institutional discrimination, with marked inequalities than the non-quilombola population of Alagoas and, even more, than the general population of the country[15–17]. This context is strongly and negatively associated with the health profile, resulting in increased vulnerability of quilombolas to a series of health problems, including anaemia. A study conducted in 2008 amongst children under five from these communities found that 52·7 % were affected by this condition[18].

Scarcity of epidemiological studies focusing on this population highlights the need for the development of research to obtain information that allows the evaluation, implementation and reorientation of specific and articulated public policies with their characteristics and peculiarities, as recommended by the WHO[6].

This study aimed to investigate factors associated with the prevalence of anaemia in children aged 6–59 months living in the quilombola communities of Alagoas.

Methods

The current analysis is based on data from the II Nutrition and Health Survey of the Afro-descendant communities of the state of Alagoas, conducted in 2018. All research procedures were approved by the ethical review board of the Federal University of Alagoas (No. 33527214.9.0000.5013). Data were collected at enrolment from children whose parents provided written informed consent. The results of the clinical examination were recorded in an appropriate form and provided to the mother or guardian. Children with anaemia or any other health problem detected during the survey received assistance by the community healthcare centre.

The sampling procedure provided for obtaining a representative sample of families from the state's quilombola communities. For this study, children aged 6–59 months (one per household) were eligible, living in 50 % of the 68 (n 34) quilombola communities of Alagoas, which were selected through systematic sampling. In the residence where there were two or more eligible children, a draw was made to define which one would participate in the study.

Data collection

Through home visits, using structured forms tested in a pilot study, trained and supervised interviewers collected demographic, socio-economic, anthropometric and health data of the mother and child. The exclusion criteria were absence of the mother or a person in charge at home who could provide information about the child and presence of sickle cell anaemia (according to the interviewed person's report).

Dependent variable

The dependent variable was child anaemia, diagnosed based on the Hb level (< 110 g/l). For this, a drop of blood was obtained by puncturing the digital pulp. This was analysed in a portable haemoglobinometer (CompoLab®). To define the degree of anaemia, the following classification was utilised: mild (100–109 g/l), moderate (70–99 g/l) and severe (< 70 g/l)[19].

https://doi.org/10.1017/S1368980020004711 Published online by Cambridge University Press

Independent variables

Socio-economic variables

The socio-economic variables included the number of individuals in residence (≤ 4; > 4); number of rooms in the house (≤ 4; > 4); family assisted by the cash transfer programme Bolsa Família (yes/no), a federal government me to address the acute needs of poor households; the Brazilian Food Insecurity Scale (*Escala Brasileira de Insegurança Alimenta,* EBIA) which has been widely used in the Brazilian population[20,21] and family economic class, according to the Brazil Economic Classification Criterion[22]. This criterion distinguished families in descending order of economic levels (A, B1, B2, C1, C2 and D–E), which were established according to a scoring system based on characteristics and possession and quantity of consumer goods at home (toilets, domestic servants, cars, microcomputer, dishwasher, refrigerator, freezer, washing machine, DVD player, microwave, motorcycle and clothes dryer, in addition to the educational level of the head of household and if the house was provided with running water and located in a paved street). Based on the score obtained, families were categorised into the following classes: A (45–100), B1 (38–44), B2 (29–37), C1 (23–28), C2 (17–22) and D–E (0–16). Due to the absence of children in families belonging to the upper strata (classes A and B1), the variable was analysed in a dichotomous manner: B + C and D–E. Additionally, due to the homogeneity observed in the distribution of households according to these classes (the maximum score found was 37, and only nine households had a score > 20), the wealth index, constructed by the analysis of main components, was also calculated from the possession at home of the same consumer goods previously described for the establishment of economic classes[23].

Maternal variables

The maternal variables were age group (< 20; ≥ 20 years), education (≤ 8; > 8 years), occupation outside the home (yes/no), height (classified in tertiles) and nutritional status, according to the classification by BMI (kg/m^2): low weight (< 18·5 kg/m^2), normal (18·5–24·9 kg/m^2), overweight (25–29·9 kg/m^2) and obesity (> 30 kg/m^2)[24].

Variables related to the child

The child-related variables were age in months (≤ 24; > 24), sex, presence of diarrhoea in the last 15 d (yes/no), self-reported skin colour as defined by the Demographic Census of the Brazilian Institute of Geography and Statistics (black/yellow; white), overweight (no/yes), slimness (no/yes), statural deficit (no/yes), vitamin A supplementation in the last 6 months (yes/no) and presence of some problems that motivated attending health service in the previous 30 d (yes/no).

Weight and height data of mothers and children were obtained following the procedures recommended by the WHO[25]. For the measurement of height, children aged > 24 months were placed in the orthostatic position in a vertical stadiometer, while the length of children aged < 24 months was verified in the dorsal decubitus position using an infantometer. Both equipment had an inextensible measuring scale with a sensitivity of 0·1 cm. The nutritional status of the children was classified based on critical *z*-scores applied to the different anthropometric indices, and the following conditions were established: stunting (stature-to-age: < –2 *z*-score), wasting (BMI-to-stature: < –2 *z*-score) and overweight (BMI-to-age: > 2 *z*-score). The anthropometric data were processed using the Anthro software (https://www.who.int/childgrowth/en/), which uses the standard curves developed by the WHO[26].

Statistical analysis

The data were input in an independent double entry, in a form generated by Epi Info® software version 3.5.4. Pearson's χ^2 test was used to compare the prevalence of anaemia according to demographic, socio-economic, environmental, morbidity and health status covariates. For independent associations with anaemia, we used the prevalence ratio (PR) and their respective 95 % CI, calculated by multiple Poisson regression models with robust variance. To this end, the independent variables were selected following a hierarchical conceptual framework by Castro *et al.*[27] with distal, intermediate and proximal levels of determination (Fig. 1), according to their crude association with the outcome at *P*-value < 0·20. At each level of determination, covariates were retained in the model if they were associated with the outcome at a *P*-value < 0·10 or if their inclusion in the model changed the adjusted R² by at least 10 %. All reported *P*-values are two-tailed, and the level of significance was set at *P* < 0·05. Statistical analyses were performed using Stata version 16.0 (StataCorp).

Results

A total of 433 children were evaluated, five of whom were excluded because they had sickle cell anaemia. Of the 428 children, 38·1 % were anaemic, 19·6 % with mild and 18·5 % with moderate form. Socio-economic indicators revealed the extreme poverty level of this population, with 93·9 % of the families belonging to the lowest economic class. Food insecurity was present in 74·8 % of households (38·6 % in moderate and severe forms). Compatible with this situation, 85·1 % of the families were beneficiaries of the Bolsa Família Program. The majority of women were self-declared black or brown and 56·2 % were overweight or obese (30·7 % overweight and 25·5 % obese). Other demographic, socio-economic and mother-related characteristics are shown in Table 1.

The crude PR for anaemia according to children characteristics is shown in Table 2. Overall, 36·7 % of the study children were aged < 24 months, 24·8 % had a diarrhoea episode in the past 2 weeks and 40·6 % had a clinical visit

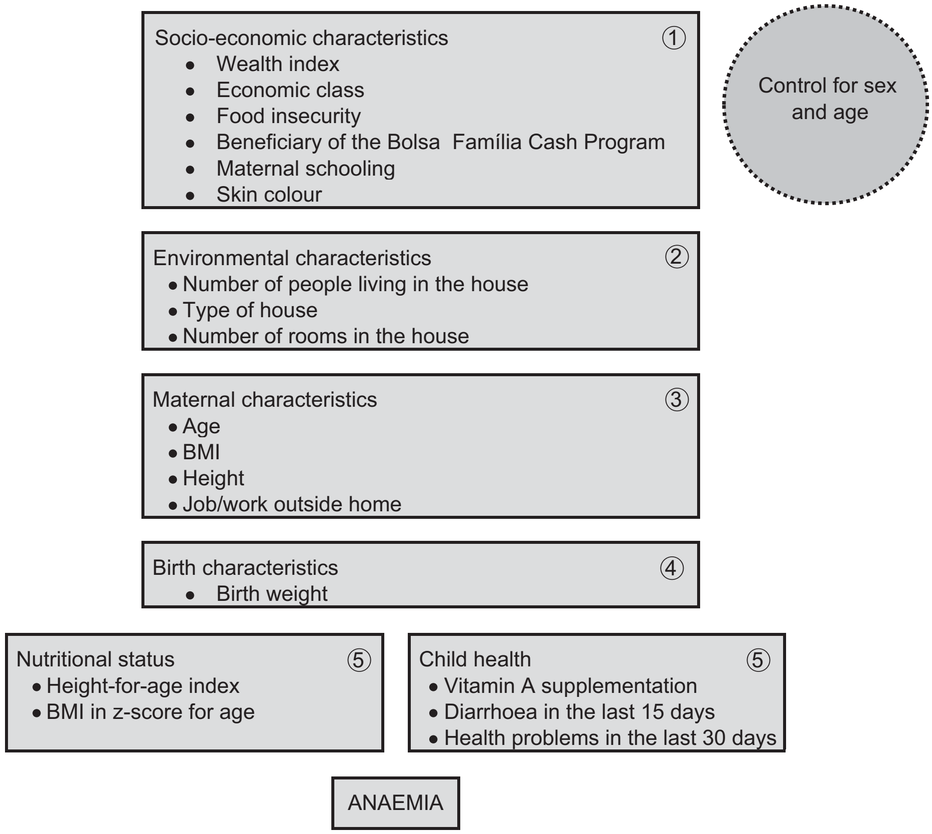

Fig. 1 Hierarchical conceptual framework for selection of associated factors with childhood anaemia (adapted from Castro *et al.*[27])

for a health problem in the last 30 d. The majority (74·3 %) had a record of vitamin A supplementation in the previous semester. Regarding nutritional status, the most prevalent conditions were overweight (9·6 %) and stunting (7·6 %).

As shown in Table 3, the variables independently associated with child anaemia were male sex (PR = 1·46; 95 % CI 1·15, 1·85), age < 24 months (PR = 1·83; 95 % CI 1·42, 2·36), number of residents at home > 4 (PR = 1·41; 95 % CI 1·11, 1·78), relatively taller mothers (PR = 1·51; 95 % CI 1·12, 2·02) and higher BMI-for-age index (PR = 1·12; 95 % CI 1·01, 1·24), after adjustment for wealth index below the median (PR = 1·21; 95 % CI 0·95, 1·55), child not receiving vitamin A supplementation in the last 6 months (PR = 1·22; 95 % CI 0·95, 1·56) and presence of some problems that have motivated attending health service in the last 30 d (PR = 1·20; 95 % CI 0·95, 1·51).

Discussion

The studied children live in a context of high social vulnerability, a condition that has been widely recognised when addressing the situation of quilombola populations in Brazil[15–17,28]. No family of the communities visited belonged to the highest economic class, while 93·9 % of them occupied the lower stratum. Consistent with this profile, 85·1 % were included in the Bolsa Família Program. A study conducted on 797 individuals from quilombola communities in Vitória da Conquista (Bahia) found that 85·6 % belonged to the lower economic class[29], a proportion slightly lower than that observed in the current study but equally alarming.

In this study, the prevalence of anaemia was a public health problem of moderate magnitude. Child anaemia was associated with demographic variables (male sex; age ≤ 24 months), environmental variables (number of residents at home > 4), maternal variables (mother classified in the upper third of the distribution of stature) and child nutritional status variables (levels of BMI score for higher age), after multiple adjustment for socio-economic variables (family with ≤median wealth index) and child morbidity variables (not receiving vitamin A supplementation in the last 6 months; having used health service during the previous 30 d).

Considering the low economic level of the quilombola populations, it is possible to assume that an important part of the children researched here do not have access to adequate food and thus would be more exposed to insufficient Fe intake and its consequences, anaemia. However, the lack of data on food consumption weakens this interpretation.

The higher prevalence of anaemia observed in boys is consistent with the results obtained in investigations conducted in both Brazil[30–33] and other countries[2,34–39].

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https://doi.org/10.1017/S1368980020004711 Published online by Cambridge University Press

Table 1 Prevalence ratios (PR) for anaemia among children aged 6–59 months (*n* 428) from Afro-descendant communities according to socio-demographic and maternal characteristics. Alagoas, Brazil, 2018

Variables	*n*	%	Anaemia, %	PR	95 % CI	*P*
Number of people living in the house						
> 4	172	40·2	42·4	1·21	0·95–1·53	0·126
≤ 4	256	59·8	35·2	1		
Number of rooms in the house						
≤ 4	100	23·4	36·0	0·93	0·69–1·24	0·614
> 4	327	76·6	38·8	1		
Beneficiary of Bolsa Família Program						
Yes	364	85·1	39·3	1·26	0·85–1·85	0·245
No	64	14·9	31·3	1		
Family economic class*						
D + E	400	93·9	38·8	1·26	0·70–2·27	0·444
B + C (wealthy)	26	6·10	30·8	1		
Food insecurity						
No	106	25·2	36·8	1		–
Mild	152	36·2	38·2	1·04	0·75–1·43	0·824
Moderate	104	24·8	35·6	0·97	0·67–1·38	0·855
Severe	58	13·8	44·8	1·22	0·83–1·78	0·308
Wealth index						
Below median value	221	51·8	42·5	1		–
Above median value	206	48·2	33·5	1·27	0·99–1·62	0·057
Maternal age (years)						
< 20	43	10·1	53·5	1·48	1·08–2·01	0·013
≥ 20	384	89·9	36·2	1		
Maternal nutritional status (BMI. kg/m^2)						
Normal (18·5–24·9)	169	40·0	42·0	1		
Underweight (< 18·5)	16	3·8	50·0	1·19	0·71–2·00	0·513
Overweight (25–29·9)	130	30·7	28·5	0·68	0·49–0·94	0·019
Obesity (>= 30)	108	25·5	40·7	0·97	0·73–1·29	0·835
Maternal height (cm)						
1º tertile (134·8–154·0)	152	35·8	31·6	1		
2º tertile (154·1–159·0)	136	32·1	40·4	1·28	0·94–1·75	0·119
3º tertile (159·1–174·6)	136	32·1	41·9	1·33	0·98–1·80	0·071
Maternal years of schooling						
< 8	205	48·9	39·0	1·10	0·86–1·41	0·458
≥ 8	214	51·1	35·5	1		–
Maternal skin colour						
Black or brown	378	88·7	38·6	1·09	0·73–1·63	0·673
White	48	11·3	35·4	1		–
Maternal job/work outside home						
Yes	139	33·6	35·2	0·93	0·71–1·22	0·612
No	275	66·4	37·8	1		

*Economic class classification by Associação Brasileira de Empresas de Pesquisa[20].

A study conducted with data collected between 2008 and 2014 on 96 804 children (6–59 months) from twenty-seven countries in sub-Saharan Africa found that the risk of anaemia among boys was 12 % higher than that of girls[34]. The physiological mechanisms involved in this relationship are not adequately elucidated; however, studies that identified a higher prevalence of anaemia in boys suggest that it is due to the more rapid growth of boys compared with that of girls, increasing the demand for Fe to meet metabolic needs, which is not always entirely met by food intake[33,38]. This increased demand may occur in foetal life in response to increased erythrocyte synthesis due to the action of erythropoietin, which under certain circumstances (e.g. maternal anaemia) would result in lower body reserves of the mineral[39]. However, several studies have not found differences in the risk of anaemia according to sex[40–43]. This points to the need for additional studies to clarify this issue.

Domellöf *et al.* (2002) aimed at identifying differences in biochemical markers that evaluate Fe status according to sex and allocated 263 4-month-old infants to two groups, who received Fe supplements or placebo for 5 months. Serial analyses of Hb level, mean corpuscular volume, zinc protoporphyrin, plasma ferritin and transferrin receptor were performed. At 9 months, the boys were ten times more at risk of being diagnosed with anaemia. It was argued that differences in Hb and transferrin receptor levels reflected an increased risk of Fe deficiency in boys, possibly because of differences in foetal Fe accumulation. However, for mean corpuscular volume and zinc protoporphyrin, the differences were independent of Fe supplementation, anthropometric variables and food intake, suggesting that other sex-related factors (genetic; hormonal) would be involved in increased male susceptibility to anaemia[38].

Table 2 Prevalence ratios (PR) for anaemia in children aged 6–59 months (*n* 428) from Afro-descendant communities according to children characteristics. Alagoas, Brazil, 2018

Variable	*n*	%	Anaemia, %	PR	95 % CI	*P*
Overall prevalence	428	100·0	38·1			
Child's age (month)						
≤ 24	157	36·7	54·8	1·93	1·52, 2·44	<0·001
> 24	271	63·3	28·4	1		–
Sex						
Male	212	49·5	43·9	1·35	1·06, 1·73	0·016
Female	216	50·5	32·4	1		–
Diarrhoea in the past 15 d						
Sim	106	24·8	38·7	1·02	0·77, 1·35	0·884
Não	322	75·2	37·9	1		–
Skin colour (self-reported)						
Black + brown	363	85·4	38·0	0·94	0·68, 1·31	0·727
White	62	14·6	40·3	1		–
Overweight (BAZ > 2 SD)						
Yes	39	9·6	46·2	1·26	0·88, 1·82	0·200
No	380	90·7	36·6	1		–
Underweight (BAZ < 2 SD)						
Yes	6	1·4	66·7	1·80	1·00, 3·21	0·047
No	413	98·6	37·1	1		–
Stunting (HAZ < –2 SD)						
Yes	32	7·6	40·6	1·09	0·70, 1·69	0·695
No	387	92·4	37·2	1		–
Vitamin A supplementation over the past 6 months						
No	109	25·7	49·5	1·46	1·14, 1·86	0·002
Yes	315	74·3	34·0	1		
Clinical visit for a health problem over the past 30 d						
Não	254	59·4	33·5	1		–
Sim	174	40·6	44·8	1·34	1·05, 1·70	0·017

BAZ = BMI for age in *z*-score; HAZ = height/length for age in *z*-score.

Table 3 Associated factors for anaemia among children aged 6–59 months from Afro-descendant communities in Alagoas, Brazil, 2018

	Crude PR			Adjusted PR*		
Variable	PR	95 % CI	*P*	PR	95 % CI	*P*
Sex						
Male *v.* Female	1·35	1·06, 1·73	0·016	1·46	1·15, 185	0·002
Child's age (month)						
≤ 24 *v.* > 24	1·93	1·52, 2·44	< 0·001	1·83	1·42, 2·36	<0·001
Number of people living in the house						
> 4 *v.* ≤ 4	1·21	0·95, 1·53	0·126	1·41	1·11, 1·78	0·005
Maternal height (tertiles)						
Highest *v.* Lowest	1·33	0·98, 1·80	0·071	1·51	1·12, 2·02	0·006
Child´s BMI for age in *z*-score (continous)						
BAZ	1·30	0·92, 1·86	0·139	1·12	1·01, 1·24	0·029

*Multiple adjusted for wealth index, vitamin A supplementation in the past 6 months, and clinical visit for a health problem in the past 30 d.

Inverse association between age and anaemia is widely described in the literature[14,18,31,44–50]. A previous study conducted in 2008 with 937 children aged 6–59 months from the quilombola communities of Alagoas, of which 52·7 % had anaemia, found a dose–response effect when comparing the prevalence of anaemia according to five growing strata of age groups. Compared with the upper stratum (48–59 months), children from the younger group (6–12 months) were five times more likely to have anaemia: 75·7 % *v.* 36·4 %[18].

The authors have explained the higher prevalence of anaemia among children aged < 24 months through the following arguments: higher growth rate in this age group, early interruption of exclusive breast-feeding under 6 months with delayed introduction of Fe-rich foods after 6 months of age and higher prevalence of diseases, such as diarrhoea and respiratory infections. Older children have reduced growth rates with increased consumption of Fe-rich foods, as they assume the usual eating patterns of the family group[46,49–52].

From the second half of the infant's life, there is an increase in the Fe requirement from 0·27 mg/d to 11·0 mg/d[53], a value that is difficult to be met by breast-feeding, although it is simultaneous with the introduction

https://doi.org/10.1017/S1368980020004711 Published online by Cambridge University Press

of new foods. On this occasion, the intake of breast milk is naturally reduced with the start of complementary feeding, contributing < 0·2 mg/d of bioavailable Fe. Under such circumstances, supplementation has been recommended[39]. Additionally, the consumption of animal protein with heme Fe is low in this age group, where a dietary pattern based on an excessive intake of milk added with flour and sugar prevails, since many families perceive these foods as nutritious and indispensable during childhood[54,55]. Despite the high prevalence among infants, the adherence of families to the recommendation of Fe supplementation is an obstacle to the effectiveness of the anaemia prevention programme in Brazil, as has also been observed in other countries[56,57].

Among the variables that integrated block 2 (characteristics of the environment) of the theoretical model adopted in the data analysis of the current study, the one that remained associated with anaemia was more than four individuals at home. Considering that the lower socioeconomic condition was also a risk factor for anaemia in the current study, this finding corroborates the premise that when there are many individuals in the family composition, there is a reduction in the per capita availability of food, especially for Fe-rich foods. In the case of children aged < 5 years, if this higher concentration is from individuals in this age group, the mother will be less available to take care of her young children[50].

The children in the current study who received vitamin A supplementation in the last 6 months had a lower prevalence of anaemia. Vitamin A deficiency (VAD) as an aetiology of anaemia has been widely recognised[2,58–61]. Vitamin A plays an essential role in Fe metabolism, so its deficiency causes damage to the proper use of this mineral. Although not all mechanisms are fully understood, the evidence suggests that, in the instance of VAD, there is a reduction in intestinal Fe absorption and tissue mobilisation, leading to decreased Hb synthesis and anaemia[59,60]. Zimmermann *et al.* conducted a clinical trial in which eighty-one children were allocated to two groups who received vitamin A or placebo. They concluded that, in children with VAD and Fe deficiency, vitamin A supplementation contributes to mobilising Fe stores and promoting increased erythropoiesis, an effect mediated by an increase in circulating erythropoietin[59].

Cunha *et al.* conducted a meta-analysis including twenty-three studies demonstrating that vitamin A supplementation reduces the risk of anaemia by 26 % and increases Hb levels, compared with the untreated group, regardless of the stage of life. They concluded that vitamin A supplementation could reduce the risk of anaemia by improving Hb and ferritin levels in individuals with low serum retinol levels[58].

The WHO, based on several publications, states that vitamin A modulates erythropoiesis and, because of its important role in immune function, it can contribute to the development of anaemia. In children with VAD, there is less mobilisation of Fe from reserves in the liver and spleen. Thus, in contrast to Fe deficiency anaemia, which is characterised biochemically by depletion of Fe stores (decreased serum ferritin level), Fe stores in the liver and spleen and increased serum ferritin levels are found in anaemia due to VAD. Vitamin A supplementation can increase Hb levels, even in the absence of Fe supplementation[2]. Obviously, the greatest impact of this strategy will occur in contexts where VAD has a vital role in the aetiology of anaemia[62].

It is important to highlight that most quilombola communities in the current study were living in the semi-arid region of Alagoas. Data from a previous population-based survey carried out in 2007 with 551 preschool children showed that 45·4 % of them had VAD, exceeding more than twice the prevalence defined by the WHO (20·0 %) as a serious public health problem, a condition that was also associated with anaemia in that region, which had been observed in 57·9 % of children[63]. Given this, it is important to increase investments to ensure vitamin A supplementation, especially in quilombola communities, as this is a measure with great potential for preventing morbidities in general, including anaemia.

In the current study, children whose mothers answered affirmatively if their children had been taken to a health service for consultation in the past 30 d presented a higher risk of anaemia when compared with those who did not use that service, and this was interpreted as an indicator of recent morbidity. Although, when comparing the prevalence of anaemia with the prevalence of diarrhoea, no significant difference was observed, it is possible that this significance was reached by its sum with other morbidities that motivated the demand of the health service. Moschovis *et al.* found that children with diarrhoea or fever had higher risk of anaemia[34].

The disease can cause anaemia through multiple mechanisms. Diseases or infections can impair the absorption and metabolism of nutrients or increase their loss. Infectious processes can also cause so-called ‘inflammation anaemia’, in which pro-inflammatory cytokines alter the metabolism of Fe, make it difficult to mobilise its deposits into the bone marrow and cause reduced production and lifespan of erythrocytes[2].

Our results showed that children with higher BMIs more frequently had anaemia, contrary to other studies in which overweight/obesity was a risk factor[2,64,65]. A WHO report[2] indicates that, in several countries, there has been an increased risk of anaemia in overweight children. This relationship would be mediated by hepcidin, a peptide hormone responsible for Fe homeostasis and produced mainly in the liver, acting to regulate the activity of the Fe exporter (ferroporin-1) and, when in excess, reduces its availability, decreasing the transport of Fe from enterocyte, hepatocyte and macrophage to the transferrin receptor and the latter to the tissues. Overweight children have high hepcidin levels and worse Fe status than normal-weight children. Obesity is also associated with subclinical inflammation, which may increase hepcidin levels[2]. However, Gajewska *et al.*[66] reveal that, when obese children have an adequate Fe

https://doi.org/10.1017/S1368980020004711 Published online by Cambridge University Press

intake, no signs of Fe deficiency are observed. In this case, considering the quilombola population context, a synergistic effect would occur between inadequate feeding (high energetic density and low nutrient level) and obesity, increasing the risk of developing anaemia.

Another possibility to justify this association is supported in the food and nutritional transition processes[67]. The change from a food pattern based on the consumption of traditional foods to one characterised by the intake of ultra-processed foods, poor in nutrients and high in energy density, would explain the increase in both BMI and risk of a multi-deficiency condition associated with anaemia. Although the food pattern of this population has not been analysed, there are studies on the changes in the eating habits of quilombola residents, attributed to the influence of a westernised diet, which is based on ultra-processed foods purchased in supermarkets, replacing foods that were previously produced in the farms and yards[68,69]. This food pattern is compatible with the high prevalence of overweight (BMI ≥ 25 kg/m^2) observed in 2008 in quilombola women in Alagoas: 52·4 %, in which 33·1 % were overweight and 19·3 % were obese[70]. In the present study conducted in a representative sample of the quilombola population of Alagoas, the prevalence of obesity among the mothers of the children was 25·5 %, suggesting a trend of positive evolution. Considering that children tend to assume the eating behaviour of their parents and that obese parents are more likely to have obese children, the upward trend of obesity in women from this population constitutes another concern related to the quality of life of quilombola residents, since obesity is related to practically all other health problems, whether predisposing, aggravating or hindering treatment.

The most unusual fact found in this work was the association between anaemia and largest maternal stature. There were no works in the literature that corroborated such finding. Subramanian *et al.* investigated the association between maternal height and some health-related outcomes, including anaemia. The study used a representative sample (n 50 750) of children aged 0–59 months and their respective mothers from all twenty-nine states in India. In the adjusted models, at each 1 cm increase in maternal height, there was a small reduction in the risk of anaemia (RR, 0·998; 95 % CI, 0·997, 0·999). However, no association between maternal height and anaemia was observed[71]. In spite of this, as previously discussed, boys aged < 5 years are more susceptible to anaemia due to high growth rate. If this is true, this same argument may justify the greater vulnerability to anaemia observed in the current study for the children of taller women, since they also tend to be taller than the children of shorter women: in order for them to be taller, they have a higher unit of stature increase than those of shorter individuals. In this case, the children of taller women would also have a higher growth rate and, therefore, a higher demand for Fe, not always fully covered by the food available in the family.

Moreover, children of taller mothers had a significantly higher mean z-score for the height-for-age index than those whose mothers belonged to the intermediate tertile or lower tertile of stature: –0·84, –0·45 and –0·16, respectively ($P < 0·001$, according to the ANOVA). However, more studies are needed to prove this association, emphasising that possible discrepancies between studies may be justified by epidemiological differentials prevailing in the different scenarios where the studies were conducted. In the case of quilombola communities, considering the socio-economic vulnerability and food insecurity present in most households, children who need a greater contribution would be at higher risk of developing anaemia and other nutritional deficiencies.

Besides the absence of food consumption data and the impossibility of establishing the temporal relationship between exposure and outcome (cross-sectional design), impairing the definition of the associations found as cause-and-effect relationships, another limitation of the present study was the impossibility of making a differential diagnosis of anaemia, since this disease was defined based only on the quantification of Hb level.

In conclusion, the prevalence of anaemia in quilombola children is quite high. The factors associated with child anaemia were male sex, aged < 24 months, more than four individuals living in the house, relatively taller mother and higher BMI, after adjusted for wealth index, vitamin A supplementation and use of health services in the last 30 d. Professionals and public policy managers should consider these characteristics to better understand the epidemiological dynamics of anaemia in this population and adopt attention measures linked to its reality. In this case, surveillance should be increased concerning nonmodifiable variables, and intervention should be made on modifiable risk factors to change them to a condition more favourable to better health levels. The need to reduce the social inequities that make this population contingent especially exposed to a greater burden of morbidities and reduced quality of life is emphasised.

Acknowledgements

Acknowledgements: The authors thank the families and health professionals as well as their research team members for their collaboration in the present study. *Financial support:* The current study was funded by the Brazilian National Council of Technological and Scientific Development – CNPq (Grants nº 442063/2014-8, 466718/2014-4) and the Foundation for Research Support of the State of Alagoas – Fapeal (Grant nº 60030.000849/2016). The views expressed in the present article are those of the authors and not necessarily those of any funding agencies. The funders had no role in the design and analysis of the study or in the preparation of the manuscript. *Conflict of interest:* None. *Authorship:* H.S.F.

https://doi.org/10.1017/S1368980020004711 Published online by Cambridge University Press

was responsible for study design and project management, supervised all study protocols, performed data analysis and interpretation and was involved in the writing of the article; L.G.M.L.S., C.M.X.F., T.R.S. and N.B.R.V. contributed to the data collection and interpretation; S.B.K. and M.L.A. were involved in the results interpretation and writing of the article. M.A.C. contributed to the data analysis, interpretation and writing the article. All authors critically reviewed the manuscript content and approved the final version. *Ethics of human subject participation:* The current study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving the research study were approved by the Research Ethics Committee of the Federal University of Alagoas (CAAE nº 33527214.9.0000.5013). Written informed consent was obtained from all research participants.

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