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Anemia and hemoglobin levels among Indigenous Xavante children, Central Brazil

Anemia e níveis de hemoglobina em crianças indígenas Xavante, Brasil Central

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ABSTRACT: ***Objective:*** To evaluate the prevalence of anemia, mean hemoglobin levels, and the main nutritional, demographic, and socioeconomic factors among Xavante children in Mato Grosso State, Brazil. ***Methods:*** A survey was conducted with children under 10 years of age in two indigenous Xavante communities within the Pimentel Barbosa Indigenous Reserve. Hemoglobin concentration levels, anthropometric measurements, and socioeconomic/demographic data were collected by means of clinical measurements and structured interviews. The cut-off points recommended by the World Health Organization were used for anemia classification. Linear regression analyses with hemoglobin as the outcome and Poisson regression with robust variance and with the presence or absence of anemia as outcomes were performed (95%CI). ***Results:*** Lower mean hemoglobin values were observed in children under 2 years of age, without a significant difference between sexes. Anemia was observed among 50.8% of children overall, with the highest prevalence among children under 2 years of age (77.8%). Age of the child was inversely associated with the occurrence of anemia (adjusted PR = 0.60; 95%CI 0.38–0.95) and mean hemoglobin values increased significantly with age. Greater height-for-age z-score values reduced the probability of having anemia by 1.8 times (adjusted PR = 0.59; 95%CI 0.34–1.00). Presence of another child with anemia within the household increased the probability of the occurrence of anemia by 52.9% (adjusted PR = 1.89; 95%CI 1.16–3.09). ***Conclusion:*** Elevated levels of anemia among Xavante children reveal a disparity between this Indigenous population and the national Brazilian population. Results suggest that anemia is determined by complex and variable relationships between socioeconomic, sociodemographic, and biological factors.

Keywords: Anemia. Deficiency diseases. Nutrition surveys. Child health. Health of indigenous peoples. Indians, South American.

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RESUMO: ***Objetivo:*** Avaliar a prevalência de anemia, os níveis médios de hemoglobina e os principais fatores nutricionais, demográficos e socioeconômicos associados em crianças Xavante, em Mato Grosso, Brasil. ***Métodos:*** Realizou-se inquérito em duas comunidades indígenas Xavante na Terra Indígena Pimentel Barbosa visando avaliar todas as crianças com menos de dez anos. Foram coletados dados de concentração de hemoglobina, antropometria e aspectos socioeconômicos/demográficos por meio de avaliação clínica e questionário estruturado. Utilizaram-se os pontos de corte recomendados pela Organização Mundial da Saúde (OMS) para a classificação de anemia. Análises de regressão linear com hemoglobina como desfecho e regressão de Poisson com variância robusta com presença ou não de anemia como desfechos foram realizadas (intervalo de confiança de 95% —IC95%). ***Resultados:*** Os menores valores médios de hemoglobina ocorreram nas crianças com menos de dois anos, sem diferença significativa entre os sexos. A anemia atingiu 50,8% das crianças, prevalecendo aquelas com menos de dois anos 2 anos (77,8%). A idade associou-se inversamente à ocorrência de anemia (razão de prevalência — RP — ajustada = 0,60; IC95% 0,38 – 0,95) e os valores médios de hemoglobina aumentaram significativamente conforme o incremento da idade. Os maiores valores de escores z de estatura-para-idade reduziam em 1,8 vez a chance de ter anemia (RP ajustada = 0,59; IC95% 0,34 – 1,00). A presença de outra criança com anemia no domicílio aumentou em 52,9% a probabilidade de ocorrência de anemia (RP ajustada = 1,89; IC95% 1,16 – 3,09). ***Conclusão:*** Elevados níveis de anemia nas crianças Xavante sinalizam a disparidade entre esses indígenas e a população brasileira geral. Os resultados sugerem que a anemia é determinada por relações complexas e variáveis entre fatores socioeconômicos, sociodemográficos e biológicos.

Palavras-chave: Anemia. Deficiências nutricionais. Inquéritos nutricionais. Saúde da criança. Saúde de populações indígenas. Índios sul-americanos.

INTRODUCTION

Anemia is considered the most prevalent nutritional deficiency in the world, affecting approximately a quarter of the population, in particular, children and women in their reproductive age[1]. In Brazil, the most recent national survey that evaluated the concentration of hemoglobin in the population indicated that 20.9% of children under 5 years of age had anemia[2]. In this investigation, important variations in the prevalence of anemia were observed between regions, varying between 10.4% in the North and 25.5% in the Northeast.

Studies about the epidemiology of anemia in Indigenous children in Brazil have been conducted in recent decades, revealing, in many cases, prevalences above 60–70%[3-5]. According to the First National Survey of Health and Nutrition of Indigenous Peoples, performed in 2008 and 2009, more than half (51.4%) of Indigenous children under 5 years of age in the country had anemia, with the highest prevalence for those under 2 years of age (74.2%)[6]. In the case of the Indigenous children, interregional differences were also observed in the distribution of anemia, but with an opposite pattern to the overall distribution revealed by the National Survey of Demography and Health (PNDS)[2], varying from 66.4% in the North to 41.1% in the Northeast[6]. Thus, the prevalence of anemia is significantly higher among Indigenous children as compared to the overall values for Brazilian children[2].

Considering evidence indicating that the disease profile is distinct among Indigenous children, there persists a need for knowledge production in the epidemiology of anemia among Indigenous populations, considering their specific environmental, economic, social, and dietary contexts. The objective of this study was to evaluate the prevalence of anemia, mean hemoglobin levels, and associated nutritional, demographic, and socioeconomic factors among Indigenous Xavante children.

METHODS

At the time of the study, the Xavante population totaled approximately 15,000, distributed among nine federally recognized Indigenous reserves in western Mato Grosso state. Pimentel Barbosa Indigenous Reserve was the largest of these by area and had the highest fertility rates, which translated into the largest proportion of young people under 15 years of age in the population (10.1% in the period from 2002 to 2004)[7].

The data from this study derived from a transversal survey performed in July 2009 with children under 2 years of age in two Xavante villages (Pimentel Barbosa and Etênhiritipá), located in the Pimentel Barbosa Indigenous Reserve. At the time of the study, the population of these two villages totaled 660 individuals (51.8% residents of Pimentel Barbosa village), of which 39.8% (263) were under 10 years of age. The study did not employ specific sampling techniques in data collection, having the aim to include all children in the age range of interest. Only children with physical or mental deficiencies were excluded.

Children's ages were calculated based on local health service records and personal identification documents in the possession of the families.

Data on place of residence, household composition, maternal education, and income were collected by means of structured interviews conducted by one of the authors and counting on the assistance of an Indigenous translator when necessary.

Weight and height measurements were taken in participants' homes by professionals who were previously trained and standardized following the recommendations of Lohman et al.[8]. Height measurements of children under two years of age were taken with a SECA 416 (Hamburg, Germany) infantometer and of the others with a SECA 214 anthropometer (Hamburg, Germany), both with a precision of 0.1 cm. Bodyweight was measured with a portable digital scale (SECA 872, Hamburg, Germany), with 150 kg capacity and 100 g precision. This scale has a mother/child weight function that allows children under 24 months of age to be weighed together with the mother or caretaker.

Hemoglobin blood concentration was measured for children over 6 months. A drop of blood was obtained from the fingertip using disposable lancets and Accu-Chek Softclix lancing device. Hemoglobin concentration was analyzed with the HemocueHb 201+ hemoglobinometer (Ängelholm, Sweden).

Children's age was classified in the following groups: < 2 years, ≥ 2 and < 5 years, and ≥ 5 years. The variable place of residence was classified according to the child's village

of residence. The two villages were identified as 1 and 2, without their proper names to guarantee confidentiality.

Stature, weight, and age data were used to calculate *z*-scores of height-for-age (H/A), weight-for-age (W/A), and body mass index-for-age (BMI/A). Z-scores were generated using the Anthro software package (WHO Anthro 2011, Switzerland) based on the World Health Organization (WHO) reference population[9,10]. Mother's BMI was classified according to WHO guidelines[11]. Maternal age was classified according to the following groups: < 18 years, ≥ 18 and < 30 years, and ≥ 30 years.

Household size was defined as the total number of residents in the child's home, classified into two groups based on the median number of individuals (14.0). The median (4.0) was also used to classify into two groups the total number of children < 5 years in the home. Mother's education was classified according to the number of years of school attended: 0 years, 1–4 years, 5–8 years, and > 8 years.

To calculate per capita income, regular monthly incomes (salaries, pensions, social assistance, social welfare benefits, and others) of all members of the household were summed and divided by the number of household members.

Classification of anemia utilized cut-off points proposed by the WHO, in addition to moderate (7–9 mg/dL) and severe (< 7 mg/dL) anemia[12,13].

Student *t*-test was used to evaluate differences between averages and Chi-squared (χ^2) and Fisher's exact tests were used to evaluate differences in proportions ($p \leq 0.05$). Some continuous variables, such as per capita income, BMI/A, H/A, and W/A, were categorized in quartiles. Initially, the association of each independent variable with hemoglobin level was evaluated by means of linear regression and with prevalence of anemia by means of Poisson regression. Independent variables showing $p \leq 0.20$ in the unadjusted analyses were considered for inclusion in the final model.

Two models were constructed in the adjusted multivariate analysis: one with hemoglobin concentration as the outcome, using linear regression coefficient (β), and the other with anemia occurrence as the outcome, using Poisson regression with robust variance. The statistical significance of Poisson regression was determined with the Wald test, estimating adjusted prevalence ratios and respective 95% confidence intervals (95%CI). The suitability of multivariate linear regression was evaluated with the F test. Multivariate stepwise analysis was used to adjust for potentially confounding variables retained from bivariate analysis. After simultaneous inclusion of all principal effects, plausible interactions were tested. Statistical modeling was conducted with the software R package (www.r-project.org), version 3.0.1, with the epicalc and sandwich packages.

The study was approved by the Research Ethics Committee at the National School of Public Health, Oswaldo Cruz Foundation, the National Research Ethics Council (CONEP authorization No. 503/2006, process No. 25000.001840/2005-14), and the National Indian Foundation (FUNAI), in accordance with National Health Council recommendations in Resolutions 466/12 and 304/00.

RESULTS

Of a total of 263 children < 10 years of age resident in the two study villages, 257 (97.7%) were evaluated. Losses were due to absence at the time of the study (n = 3; 1.1%), data inconsistencies (n = 1; 0.4%), impossibility of data collection due to physical limitations of the child (n = 1; 0.4%), and refusal to participate (n = 1; 0.4%).

The lowest mean hemoglobin values were found among children < 2 years old, without significant difference between the sexes in any age group (Table 1). Anemia was observed in 50.8% of children and was more frequent among those < 2 years (77.8% for both sexes) and from 2 to 5 years (50.5%). Considering children < 5 years (n = 143; 55.4%), 62.2% had anemia (data not shown in table). Moderate and severe anemia also occurred with greater frequency in children < 2 years old (25.9% of the children in this age group). Among those < 2 years old, the proportion of cases classified as moderate or severe was 13.0%. The male sex showed higher percentages of anemia independently of age, but this difference was not significant (Table 1).

Child's age was inversely associated with the occurrence of anemia (Table 2). Consequently, mean hemoglobin concentration levels increased significantly with each age increment. Children with H/A *z*-scores in the first quartile (*z*-score ≤ -1.82) showed the highest frequency of anemia (data not represented in table). A similar pattern was observed for the W/A index, as well as mean hemoglobin levels (Table 2).

Table 1. Prevalence of anemia and moderate to severe anemia and mean hemoglobin levels among Xavante children > 6 months and < 10 years of age according to sex and age group. Pimentel Barbosa and Etênhiritipá villages, Mato Grosso, Brazil, 2009.

Age (years)	Total (n)	Without anemia n (%)		Anemia n (%)			Moderate/ severe anemia n (%)			Mean hemoglobin level g/dL (±SD)			
		Boys	Girls	Boys	Girls	p-value*	Boys	Girls	p-value*	Boys	Girls	p-value**	Total
< 2	54	4 (7.4)	8 (14.8)	20 (37.0)	22 (40.7)	0.379	10 (18.5)	4 (7.4)	0.061	9.08 (1.41)	9.7 (1.32)	0.103	9.43 (1.38)
≥ 2 and < 5	89	20 (22.5)	24 (27.0)	22 (24.7)	23 (25.8)	0.743	1 (1.1)	2 (2.2)	0.736	10.64 (1.31)	10.74 (1.34)	0.703	10.70 (1.25)
≥ 5	115	36 (31.3)	35 (30.4)	23 (20.0)	21 (18.3)	0.807	1 (0.9)	1 (0.9)	NA	11.47 (1.26)	11.26 (1.17)	0.365	11.37 (1.22)
Total	258	60 (23.2)	67 (26.0)	65 (25.2)	66 (25.6)	0.703	12 (4.7)	7 (2.7)	0.410	10.74 (1.53)	10.73 (1.39)	0.971	10.73 (1.46)

SD: standard deviation; NA: not applicable; *χ^2 or Fisher's exact test (95% confidence interval – 95%CI); **Student *t*-test (95%CI).

Table 2. Unadjusted prevalence ratio of anemia and linear coefficient of hemoglobin concentration according to independent variables among Xavante children > 6 months and < 10 years of age. Pimentel Barbosa and Etênhiritipá villages, Mato Grosso, Brazil, 2009.

Variables	n	Anemia		Hemoglobin	
		PR (95%CI)	p-value	β (95%CI)	p-value
Age (years)					
< 2	54	Ref (1)		Ref (0)	
≥ 2 and < 5	89	0.65 (0.43 – 0.99)	0.045	1.11 (0.70 – 1.52)	< 0.001
≥ 5	115	0.49 (0.32 – 0.75)	0.001	1.85 (1.46 – 2.24)	< 0.001
Sex					
Female	125	Ref (1)		Ref (0)	
Male	133	0.95 (0.68 – 1.34)	0.789	0.04 (-0.31 – 0.38)	0.837
Place of residence					
Village 1	137	Ref (1)		Ref (0)	
Village 2	121	1.19 (0.84 – 1.67)	0.331	-0.24 (-0.58 – 0.10)	0.169
Height-for-age (quartile)					
1st	67	Ref (1)		Ref (0)	
2nd	63	0,64 (0,40 – 1,02)	0,060	0,52 (0,07 – 0,98)	0,025
3rd	63	0,76 (0,49 – 1,19)	0,231	0,67 (0,22 – 1,13)	0,004
4th	65	0,46 (0,27 – 0,76)	0,003	1,21 (0,75 – 1,66)	< 0,001
Weight-for-age (quartile)					
1st	66	Ref (1)		Ref (0)	
2nd	63	0,76 (0,48 – 1,22)	0,259	0,50 (0,03 – 0,98)	0,039
3rd	63	0,83 (0,52 – 1,31)	0,413	0,56 (0,08 – 1,04)	0,021
4th	65	0,65 (0,40 – 1,06)	0,087	0,61 (0,13 – 1,08)	0,013
BMI-for age (quartile)					
1st	64	Ref (1)		Ref (0)	
2nd	64	1,14 (0,69 – 1,90)	0,606	-0,07 (-0,55 – 0,41)	0,773
3rd	65	1,48 (0,92 – 2,38)	0,110	-0,43 (-0,91 – 0,05)	0,078
4th	62	0,96 (0,56 – 1,63)	0,876	-0,05 (-0,53 – 0,43)	0,840

Continue...

Tabela 2. Continuation.

Variables	n	Anemia		Hemoglobin	
		PR (95%CI)	p-value	β (95%CI)	p-value
Maternal BMI					
Adequate (≥ 18.5 and < 25.0 kg/m²)	38	Ref (1)		Ref (0)	
Overweight (≥ 25.0 and < 30.0 kg/m²)	119	1,01 (0,60 – 1,69)	0,975	-0,10 (-0,62 – 0,42)	0,711
Obesity (≥ 30.0 kg/m²)	16	0,97 (0,55 – 1,71)	0,915	-0,16 (-0,73 – 0,41)	0,576
Maternal age (years)					
< 18	29	Ref (1)		Ref (0)	
≥ 18 and < 30	179	0,74 (0,45 – 1,21)	0,226	0,79 (0,25 – 1,34)	0,005
≥ 30	48	0,61 (0,33 – 1,15)	0,128	1,15 (0,51 – 1,79)	< 0,001
Maternal anemia					
No	111	Ref (1)		Ref (0)	
Yes	130	0,99 (0,69 – 1,41)	0,950	-0,02 (-0,37 – 0,33)	0,915
Number of children < 5 years in the home					
< 4	110	Ref (1)		Ref (0)	
≥ 4	148	1,17 (0,82 – 1,66)	0,392	-0,26 (-0,60 – 0,09)	0,142
Household size (residents)					
< 14	124	Ref (1)		Ref (0)	
≥ 14	134	1.20 (0.85 – 1.70)	0.298	-0.20 (-0.54 – 0.14)	0.240
Another child in household with anemia					
No	69	Ref (1)		Ref (0)	
Yes	189	2.07 (1.27 – 3.36)	0.003	-0.63 (-1.01 – -0.25)	0.001
Maternal education (years)					
0	78	Ref (1)		Ref (0)	
1 to 4	120	1.12 (0.74 – 1.69)	0.590	-0.32 (-0.71 – 0.07)	0.111
5 to 8	55	1.18 (0.73 – 1.92)	0.499	-0.56 (-1.04 – -0.09)	0.021
> 8	0	NA	NA	NA	NA
Per capita income					
Low and medium°	194	Ref (1)		Ref (0)	
High°°	64	0.82 (0.54 – 1.25)	0.364	0.40 (0.01 – 0.79)	0.045

PR: Unadjusted prevalence ratio; β: linear coefficient; 95%CI: 95% confidence interval; BMI: body mass index; NA: not applicable; °equivalent to the first 3 quartiles; °°equivalent to the upper quartile.

Maternal age showed a direct association with children's mean hemoglobin levels (Table 2). Maternal age ≥ 30 years resulted in an average increase of 1.15 mg/dL in the child's hemoglobin concentration. However, an association between maternal and child anemia child was not detected.

Another factor associated with anemia and with mean hemoglobin concentration was presence of another child with anemia in the household (Table 2). On the other hand, mother's educational level was inversely associated with hemoglobin concentration: 5–8 years of schooling resulted in an average decrease of 0.56 mg/dL in the child's hemoglobin concentration. Also standing out among socioeconomic indicators was a direct association between per capita income and average hemoglobin concentration.

The variables tested and those that remained in the final model for hemoglobin concentration were the following: age group, H/A, presence of another child with anemia in the

Table 3. Adjusted prevalence ratio of anemia and parameters of multiple linear regression for hemoglobin concentration between independent variables among Xavante children > 6 months and < 10 years of age. Pimentel Barbosa and Etênhiritipá villages, Mato Grosso, Brazil, 2009.

Variables	Anemia		Hemoglogina		
	(95%CI)	p-value*	β (95%CI)	p-value	p-value**
Age (years)					
< 2	Ref (1)		Ref (0)		< 0.001
≥ 2 and < 5	0.73 (0.48 – 1.12)	0.153	1.07 (0.66 – 1.49)	< 0.001	
≥ 5	0.60 (0.38 – 0.95)	0.029	1.62 (1.21 – 2.04)	< 0.001	
Height-for-age (quartile)					
1st	Ref (1)		Ref (0)		0.049
2nd	0.79 (0.49 – 1.28)	0.332	0.14 (-0.31 – 0.59)	0.546	
3rd	0.94 (0.59 – 1.48)	0.779	0.40 (-0.10 – 0.89)	0.117	
4th	0.59 (0.34 – 1.00)	0.050	1.03 (0.43 – 1.62)	< 0.001	
Another child in household with anemia					
No	Ref (1)		Ref (0)		0.008
Yes	1.89 (1.16 – 3.09)	0.011	-0.46 (-0.79 – -0.13)	0.006	
Per capita income					
Low and medium°	NA		Ref (0)		0.035
High°°	NA	NA	0.38 (0.05 – 0.72)	0.025	

*Wald test; **F test; °equivalent to the first 3 quartiles; °°equivalent to the upper quartile; NA: not applicable for not remaining in the final model.

household, and per capita household income (Table 3). Together, these variables explained 32% of the variation in hemoglobin concentration among investigated children. All these variables except per capita household income also remained associated with anemia in the final model. The chance of children ≥ 5 years having anemia was reduced by 66.0% (PR adjusted = 0.60; 95%CI 0.38 – 0.95) when compared to the others. Having a better nutritional state as measured by H/A reduced the chance of having anemia by 1.8 times (PR adjusted = 0.59; 95%CI 0.34 – 1.00). Presence of another child in the household increased the chance of anemia by 52.9% (PR adjusted = 1.89; 95%CI 1.16 – 3.09) (Table 3).

DISCUSSION

The low hemoglobin levels and elevated prevalence of anemia observed among Xavante children find parallel in epidemiological studies conducted in other Indigenous groups in Brazil over the last decade[4,14-16]. Previous surveys conducted in the Pimentel Barbosa Indigenous Reserve and other Xavante communities also point to elevated frequencies of anemia, reaching three quarters of all children[17]. Thus, anemia is a prominent and persistent nutritional issue for Xavante children.

Comparing the prevalence of anemia among Indigenous children < 5 years old nationally (51.2%) and in the Central-West region (51.5%) with that documented in the present study (62.2%), the Xavante present a less favorable scenario[6]. However, epidemiological studies of anemia among Indigenous children < 5 years old in communities in the Southeast and North regions of the country similarly showed prevalence rates higher than 60%[3,5].

Anemia prevalence rates among Xavante children are considerably higher when compared with the national non-Indigenous population, reaching a three-fold difference[2]. Similarly expressive differences in the occurrence of anemia in Indigenous and non-Indigenous populations have also been observed in other countries. For example, based on a systematic review of anemia epidemiology in 13 countries, including Brazil, Khambalia et al.[18]. showed that the prevalence is often higher among Indigenous peoples than among other segments of the population in the same country or region. These authors highlight that iron deficiency anemia is preventable and, most often, associated with food insecurity, poor sanitation, and a high burden of infectious and parasitic diseases[18]. Likewise, diverse studies highlight that infectious and parasitic diseases, especially diarrhea and pneumonia, and undernutrition constitute the principal causes of disease and death among Xavante children. This scenario is consistent with the elevated prevalence of anemia observed in this study[19-21].

Age of the child was an important explanatory factor for hemoglobin concentration and prevalence of anemia among the Xavante, which is comparable with observations from other studies of Indigenous[4-6,14] and non-Indigenous populations[22,23] in Brazil. The age group < 2 years old is recognized as the most vulnerable phase of life for nutritional and infectious disesases[24]. Furthermore, this period is characterized by intense physical growth, which increases the demand for micronutrients such as iron, folic acid, and vitamin B12.

Introduction of low iron foods during weaning and high prevalence of diarrhea and pneumonia are also important factors associated with childhood anemia[23,24].

As observed in other studies[6,16,18,23], Xavante children with linear growth deficits also showed higher prevalence of anemia, suggesting a relation between undernutrition and low hemoglobin levels. However, some studies conducted among Indigenous peoples[5,18,25] as well as among non-Indigenous peoples[26-28] do not document this association, suggesting it is multicausal. The determination of nutritional status, including anemia, is related to numerous factors including socioeconomic condition, basic sanitation, occurrence of infectious and parasitic diseases, and diet, among others.

The relationship between sex and child anemia is also not uniform, with some studies indicating an association[27,29] while others do not[22]. In the sample of children investigated in the First National Survey of Health and Nutrition of Indigenous Peoples, boys showed a higher chance of having anemia in Brazil[6]. Among the Xavante, the frequency of anemia was greater among boys but the difference was small and not significant.

Concerning maternal characteristics, children of anemic and younger mothers were not shown be more anemic. Iron deficiency during pregnancy is generally associated with low birth weight and preterm birth.[23,28] In the case of the Xavante, the absence of a significant relation may be due to the fact that children tend to be born with adequate weight and only suffer growth deceleration in the third or fourth month of life[30]. However, mean hemoglobin levels in children showed a direct relationship with the mother's age, consistent with findings from other studies of non-Indigenous and Indigenous children[6,29]. Lower child hemoglobin concentration levels may be related to observation that younger mothers have greater chances of giving birth to children with low weight[27,31].

Presence in the household of another child < 10 years with anemia was significantly associated with the occurrence of anemia. This relationship may result from the household environment shared by Xavante children, which involves mutual exposure to a common set of socioeconomic, physical, and dietary factors.

Among the socioeconomic variables analyzed in this study, maternal education and per capita income were shown to be determining factors for mean hemoglobin levels but not anemia occurrence. This pattern is consistent with what is observed in the national Indigenous and non-Indigenous populations, according to which maternal education and socioeconomic status operate as protective factors for the occurrence of anemia in children[6,31]. As was mentioned above, there is a complex relationship between anemia and socioeconomic conditions, potentially intermediated by diverse factors including sanitation, infectious and parasitic diseases, and diet.

Different results for relationships between socioeconomic variables and the two indicators of iron deficiency, anemia and mean hemoglobin levels, among Xavante children should be interpreted not only in terms of their specific socioeconomic context, but also in light of studies recently undertaken with other Indigenous groups in Brazil that did not indicate a uniform relationship between traditional socioeconomic indicators and child health[5,21,32], possibly because local Indigenous economies often involve different dynamics

from the national economy. Due to a tendency for physical and sanitation characteristics of Xavante households in Pimentel Barbosa village to be uniform, we did not evaluate other variables typically used to characterize the socioeconomic profile of rural households and commonly considered "protective" with regard to the anemia occurrence, such as type of flooring, roofing, waste disposal, and/or source of drinking water.

Other factors considered important in the determination of child anemia and hemoglobin levels, such as mother's gestational age, birth weight, and breastfeeding, were not investigated in this study. This was mainly due to the impossibility of obtaining reliable data from local health services. Another limitation of this study is that it did not collect data that permitted identifying the etiology of anemia in Xavante children. However, it is very likely that the disease is due to a lack of dietary iron (iron deficiency anemia) given the local inexistence of malaria, a disease known to cause anemia, and the low prevalence of helminths such as hookworm, due to regular use of broad spectrum anthelmintics in the population[33-35]. Also, population genetics studies among the Xavante since the 1960s did not find sickle cell trait or any other indication of hereditary anemia[17].

The high prevalence of anemia observed among Xavante children may find explanation in a series of factors including food insecurity, a high incidence of gastrointestinal infections, and limited access to health programs and services. The recent history of the Xavante people is marked by rapid and profound changes in ecology, subsistence and dietary patterns, and physical activity[7,36]. These changes strongly affect children, especially those under 5 years of age, among whom almost 30% have linear growth deficits[21,30]. Diarrhea accounts for approximately 75% of hospitalizations caused by infections and parasitic diseases, which are responsible for 20% of all hospitalizations[19]. As is amply documented, diarrhea is an important factor in the determination of child nutritional status, including anemia. Data from the First National Survey of Health and Nutrition of Indigenous Peoples demonstrated the association between diarrhea and anemia in Indigenous children[37], which finds support in the international literature[38]. It is also important to mention the National Iron Supplementation Program, an action developed in 2003 as part of the Indigenous Food and Nutrition Surveillance System (SISVAN Indígena)[39] and which for various reasons reaches less than half of the target population of Indigenous children under five years[6].

CONCLUSION

Anemia constitutes an important health challenge for Indigenous children, with observed prevalence rates being much higher than in the rest of the Brazilian population in the same age group. It is a nutritional deficiency influenced by complex socioeconomic and demographic factors, as shown in the present study, with potentially important consequences for child growth and development. Identification of determinant factors for anemia in Indigenous populations, which do not always follow observed patterns in the general population, contributes to the development of specific actions that are appropriate for the particularities

of these societies and thereby contribute to the improvement of sanitary and nutritional conditions and the reduction of disparities between health indicators for Indigenous and non-Indigenous people in Brazil. Specifically, our results call attention to a higher risk of anemia for children < 2 years with linear growth deficit and living with other anemic children, independently of the socioeconomic condition of the household.

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