Rev Saúde Pública 2007;41(3)

Maria Cecília Formoso Assunção[I]

Iná da Silva dos Santos[II]

Aluísio Jardim Dornellas de Barros[II]

Denise Petrucci Gigante[I]

César Gomes Victora[II]

Anemia in children under six: population-based study in Pelotas, Southern Brazil

ABSTRACT

OBJECTIVE: To assess the prevalence of anemia among children under six years of age in a probabilistic sample from an urban area.

METHODS: A study was conducted comprising children aged zero to five years in the city of Pelotas, Southern Brazil, in 2004. Data were collected on demographic, socioeconomic, and anthropometric characteristics, morbidity and nutrition using a questionnaire applied to the mothers and guardians. Children's weight and height measurements were obtained. Hemoglobin concentration was measured using the HemoCue portable hemoglobinometer and anemia was defined as hemoglobin <11 g/dL. The association between anemia and predictors was expressed as prevalence ratio. Multivariate analysis was carried out using Poisson regression following a conceptual model and taking into account the study design effect.

RESULTS: There were identified 534 children and total losses and refusals were 27 (5.1%). The prevalence of anemia was 30.2% (95% CI 23.5%;37.0%). In the multivariate analysis, only age and family income remained significantly associated with anemia.

CONCLUSIONS: Anemia was largely socially determined in the population studied. Interventions aiming at reducing anemia should be developed to lessen this condition in the short run targeting disadvantaged populations.

KEYWORDS: Anemia, epidemiology. Child. Risk factors. Cross-sectional studies.

INTRODUCTION

Iron deficiency is the most common and widespread nutritional deficiency worldwide. Although the terms iron deficiency and iron deficiency anemia are used as synonymous they are not the same condition. Iron deficiency occurs when there is a long-term negative iron imbalance and anemia is the most severe stage of this deficiency.[18]

The prevalence of anemia due to iron deficiency is hardly ever directly estimated because specific indicators of iron stores in the body (serum ferritin, saturation of transferrin, zinc protoporphyrin, and receptors of serum transferrin) are more difficult to be measured than hemoglobin levels. However, the prevalence of iron deficiency anemia can be estimated assuming that about 90% of anemia cases are due to iron deficiency.[18]

Iron deficiency anemia causes impairment of body functions. In children, this condition has been associated with child development retardation, compromised cellular immunity and reduced intellectual capacity,[8] although the latter in not a consensus in the literature.[9]

I Faculdade de Nutrição. Universidade Federal de Pelotas (UFPel). Pelotas, RS, Brasil.

II Programa de Pós-graduação em Epidemiologia. UFPel. Pelotas, RS, Brasil

Correspondence:
Betzabeth Slater
Departamento de Nutrição - 2º andar
Av. Dr. Arnaldo, 715 Cerqueira César
01246-904 São Paulo, SP, Brasil
E-mail: bslater@usp.br

Received: 4/20/2006
Reviewed: 10/18/2006
Approved: 11/23/2006

Besides children, pregnant women are also susceptible to iron deficiency. International organizations have associated iron deficiency with adverse pregnancy outcomes, such as increased risk of maternal and perinatal mortality as well as low birth weight.[18] However, systematic literature reviews have indicated a lack of well-designed studies on the subject.[3]

Many factors can contribute to the development of anemia such as genetic diseases, infections and deficiency of several nutrients. Nevertheless, endemic anemia during childhood is believed to result from a combination of exceptionally high demands of iron required for child growth and iron-poor diets especially those deficient in highly bioavailable iron.[11]

Anemia affects people in both developed and developing countries.[12] In Brazil, population-based studies show high prevalences of anemia ranging between 30% and 60%.[1,7,10,11,13-15]

In the light of that, the Brazilian government has established that, from July 2004, wheat and corn flours produced and marketed in Brazil would be fortified with iron and folic acid (Resolution No. 344 of the Brazilian National Health Surveillance Agency). The present study had the purpose of assessing the prevalence of anemia in a sample of children under six before the implementation of this resolution.

METHODS

This is a population-based study conducted in the urban area of the city of Pelotas, Southern Brazil, between May and June 2004. The survey was the baseline of an impact evaluation — pre- and post-intervention — to assess the effect of iron fortification of wheat and corn flours on the development of anemia in preschool children.

The sample was estimated for an intervention study to detect a difference of 0.5 g/dL in mean hemoglobin between pre- and post-intervention surveys. For this intent, 600 children aged zero to 71 months would be required in each phase of the study, considering a 95% confidence level (two-sided), 90% power and a standard deviation of 1.7 g/dL hemoglobin.[10]

The sample was selected by clusters in two steps and primary sampling units were drawn from census tracts defined by the Instituto Brasileiro de Geografia and Estatística (Brazilian Institute of Geography and Statistics, IBGE) for 2000 Demographic Census. Twenty census tracts were selected with a size-proportional probability (estimated number of children in the age group of interest). The number of households in each tract was determined to allow identifying 30 children on average per tract, making a total of 600 children required. In each tract a street corner was drawn to be the study starting point and, from there, to systematically select the households to be visited. All children under six years in every household were included in the study. The sample was designed to be representative of children under six living in the city's urban area. Since a weaker association was expected between anemia and socioeconomic condition, the sample size estimate did not include the correction for design effect.

Data collection comprised the application of a questionnaire to mothers or guardians by previously trained nutritionists. Data was collected on demographic (gender, age in months, skin color, birth weight, current weight and height); socioeconomic characteristics (current family income in reals, maternal and paternal schooling in full years of study, sanitation conditions and crowding); prior history of anemia (anemia diagnosed by a physician in the last year and use of drug therapy); dietary patterns (weekly intake of iron-rich food; breastfeeding; and intake of macro and micronutrients assessed using a 24-hour food recall, excluding the day following Sundays and holidays).

Weight measures of children were obtained using digital electronic scales (Seca) with 150-kg capacity and 100-g precision (Unicef, Copenhagen). Length measurements of children aged up to 2 years were obtained using anthropometers (Sanny), belt model, with 20 to 105-cm scale and 0.5-cm precision. Height of older children was obtained using an Alturaexata stadiometer with 35 to 213-cm scale and 0.1-cm precision.

Nutritional status was assessed using the National Center for Health Statistics[5] criteria for the comparison of anthropometric ratios obtained based on length/height and weight measures and age. Children were classified as having growth deficit when their height/age ratio was below -2 standard deviations and as overweight when their weight/height ratio was greater than 2 standard deviations as proposed by the World Health Organization.[17]

To ascertain repeatability of data collected, 10% of interviews in each census tract were systematically selected and repeated by the field work supervisor using an abbreviated questionnaire. Interviewers did not know which households would be revisited. Kappa coefficients for the variables studied (skin color, maternal and paternal schooling) were all higher than 0.85.

Hemoglobin measurement in the peripheral blood was obtained by finger prick and readings were made in a portable hemoglobinometer (HemoCue AB, Sweden), which was calibrated daily as per the manufacturer's specifications. Hemoglobin concentration was expressed in g/dL and those children with hemoglobin concentration below 11 g/dL[18] were classified as anemic.

Data were double entered and transferred to electronic files using EpiInfo 6.04. After data entry, consistency was ascertained. The analysis was conducted using Stata 8.0 and there were first carried out descriptive analyses of the variables collected. The sample design was taken into account in the entire data analysis to correct estimates of the variability of intra-cluster correlation. Bivariate and multivariate analyses were conducted using Poisson regression and results were described as prevalence ratios.[2]

Multivariate analysis was based on a previously developed conceptual model in which four hierarchical levels of anemia were considered. The first level included socioeconomic and demographic variables; the second level included children's characteristics at birth; the third level included anthropometric indicators and awareness of anemia; and, the fourth level included children's dietary patterns. Those variables that met the criteria for potential confounders[4] with association to p<0.20 were included in the multivariate analysis.

The study was approved by the Research Ethics Committee of the School of Medicine of Universidade Federal de Pelotas. The mother's or guardian's written consent was obtained before data and blood collection. The study did not imply in any risks to the children's health. Parents or guardians of those diagnosed with anemia were warned and their children were referred to health care services for treatment.

RESULTS

Of 20 census tracts selected, 534 children aged between zero and five years were identified. Of them, 27 (5.1%)

Table 1. Sample description according to demographic, socioeconomic and anthropometric characteristics of children. Pelotas, Southern Brazil, 2004.

Characteristic	Total number of children (N=507)	%	Sample percent with hemoglobin measurement (N=453)
Gender			
Male	266	52.5	90.6
Female	241	47.5	88.0
Skin color*			
White	376	74.5	87.0
Non-white	129	25.5	96.1
Age (months)			
< 12	82	16.2	87.8
12-23	64	12.6	90.6
24-35	83	16.4	86.7
36-47	86	17.0	94.2
48-59	92	18.1	89.1
60-71	100	19.7	88.0
Maternal schooling (full years) **			
No schooling	32	6.3	84.4
Up to 4 years	111	22.0	95.5
5 - 8 years	193	38.4	91.2
9 - 11 years	131	26.0	89.3
12 years or more	37	7.3	64.9
Family income (minimum wages)			
Less than 1	90	17.8	90.0
1 - 2.99	261	51.5	93.9
3 - 5.99	101	19.9	87.1
6 or more	55	10.9	70.9
Nutritional status (standard deviation)			
Height/age < -2	28	5.5	85.7
Weight/height > 2	61	12.0	90.2

* Two unknown observations
** Three unknown observations

were not included in the study: 13 were not found after at least four visits to their household and 14 because the mother did not consent with their participation in the study.

Of 507 children recruited, 52% were males and 75% were white. Their mean age was 3.7 years (SD=1.7 years), about 30% were less than 24 months of age and 70% were children of parents with five or less years of schooling. Seventy percent belonged to families with

Table 2. Prevalence of anemia and crude prevalence ratios according to socioeconomic and demographic characteristics of children. Pelotas, Southern Brazil, 2004. (N=453)

Characteristic	N	Prevalence of anemia (%)	Prevalence ratio	95% CI	p-value*
Skin color					0.006
White	327	25.7	1.00		
Non-white	124	42.7	1.66	1.18;2.34	
Age (months)					0.02 **
< 12	72	36.1	1.00		
12-23	58	32.8	0.91	0.55;1.50	
24-35	72	41.7	1.15	0.80;1.67	
36-47	81	30.9	0.85	0.56;1.30	
48-59	82	22.0	0.61	0.39;0.94	
60-71	88	21.6	0.60	0.31;1.11	
Gender					0.09
Male	241	27.0			
Female	212	34.0	1.25	0.96;1.65	
Maternal or guardian's schooling (full years)					< 0.001**
No schooling	27	51.9	1.00		
Up to 4	106	43.4	0.84	0.52;1.35	
5-8	176	29.0	0.56	0.38;0.81	
9-11	117	18.0	0.35	0.22;0.56	
11 or more	24	16.7	0.32	0.14;0.76	
Father's or partner's schooling (full years)					<0.001**
No schooling	16	62.5	1.00		
Up to 4	96	34.4	0.55	0.32;0.95	
5-8	193	29.5	0.47	0.26;0.87	
9-11	91	16.5	0.26	0.15;0.46	
11 or more	14	14.3	0.23	0.09;0.55	
Family income (minimum wages)					<0.001**
< 1	81	50.6	1.00		
1-2	245	29.4	0.58	0.46;0.73	
3-5	88	25.0	0.49	0.34;0.72	
6 or more	39	5.1	0.10	0.05;0.19	
Total residents					0.007**
2 - 4	201	26.4	1.00		
5 - 7	210	31.0	1.17	0.84;1.65	
8 - 14	42	45.2	1.72	1.20;2.45	
Low birth weight					0.24
No	406	29.6	1.00		
Yes	47	36.2	1.22	0.87;1.73	

* Poisson regression taking into account the design effect
** Poisson regression with the linear trend test

income lower than three minimum wages. About 5% of them had height deficit and 12% had overweight according to the indicators used in the study.

Hemoglobin was measured in 89.3% (N=453) children. The 54 children whose parents or guardians did not allow hemoglobin testing did not differ as for gender and age from the rest of the sample. However, there was a statistically significant association between these refusals and maternal and paternal schooling and family income. These children were mostly born to parents with more than five years of schooling and around 40% came from families with income greater than six minimum wages. Table 1 shows the distribution of the sample studied.

Table 3. Prevalence of anemia and crude prevalence ratios according to prior diagnosis of anemia reported by the physician and anthropometric indicators. Pelotas, Southern Brazil, 2004. (N=453)

Characteristic	N	Prevalence of anemia (%)	Prevalence ratio	95% CI	p-value*
Prior diagnosis of anemia					0.17
No/does not recall	261	27.6	1.00		
Yes	192	33.9	1.23	0.91;1.65	
Use of anemia drug therapy in the last year					0.02
No/does not recall	313	26.8	1.00		
Yes	140	37.9	1.41	1.07;1.85	
Height/age < -2 SD					0.42
No	429	29.8	1.00		
Yes	24	37.5	1.26	0.71;2.23	
Weight/height >2 SD					0.03
No	398	32.1	1.00		
Yes	55	16.4	0.51	0.28;0.93	

* Poisson regression taking into account the design effect

Table 4. Prevalence of anemia and crude prevalence ratios according to dietary patterns of children. Pelotas, Southern Brazil, 2004. (N=453)

Characteristic	N	Prevalence of anemia (%)	Prevalence ratio	95% CI	p-value*
Breastfeeding					0.09
No	33	45.5	1.00		
Yes	418	29.2	0.64	0.38;1.09	
Weekly intake of red meat					0.17
No	89	36.0	1.00		
Yes	336	28.0	0.77	0.54;1.12	
Weekly intake of liver					0.55
No	331	29.0	1.00		
Yes	94	31.9	1.10	0.79;1.53	
Weekly intake of yolk					0.08
No	153	36.0	1.00		
Yes	272	26.1	0.72	0.51;1.04	
Weekly intake of beans					0.27
No	21	38.1	1.00		
Yes	406	29.3	0.77	0.47;1.25	
Inadequate intake of iron					0.05
No	374	28.3	1.00		
Yes	79	39.2	1.38	1.00;1.91	

* Poisson regression taking into account the design effect

Table 5. Adjusted prevalence ratios* of anemia according to the hierarchical model of analysis. Pelotas. Southern Brazil. 2004.

Characteristic	Adjusted prevalence ratio (95% CI)	p-value**
Age (months)		0.02***
< 12	1.00	
12-23	0.91 (0.56-1.48)	
24-35	1.00 (0.65-1.55)	
36-47	0.83 (0.55-1.25)	
48-59	0.53 (0.36-0.80)	
60-71	0.58 (0.32-1.07)	
Family income (minimum wages)		0.01***
Less than 1	1.00	
1 - 2.99	0.69 (0.46-1.05)	
3 - 5.99	0.65 (0.39-1.10)	
6 or more	0.13 (0.05- 0.33)	

* Adjusted for age and income
** Poisson regression taking into account the design effect
*** Poisson regression with the linear trend test

Capillary hemoglobin ranged between 5.9 and 16.7 g/dL, the mean was 11.3 g/dL and the standard deviation was 2.8 g/dL. The overall prevalence of anemia (hemoglobin <11 g/dL)[18] was 30.2% (95% CI: 23.5%;37.0%). Hemoglobin measures indicative of severe anemia (hemoglobin <7 g/dL)[18] were detected in less than 1% of the children studied.

Intra-class correlation coefficient for the categorical variable (anemia) was 0.07 and the design effect was 2.5; and the latter was taken into consideration in all analyses.

Table 2 shows anemia was significantly more prevalent in non-white, younger children born to parents with up to four years of schooling. It was also noted that the higher the family income, the more protected children were against anemia. The risk of developing anemia also increased as more people lived in the same household.

Table 3 shows that those children who had drug therapy in the last year had a prevalence of anemia around 40% higher than those whose mother did not report treatment. Anemia was not associated with malnutrition but it was about 50% less often seen among overweight children.

In regard to dietary patterns, only inadequate iron intake assessed through the 24-hour food recall was found to be associated to anemia. Children who had iron intake below the recommended daily amount[6] were about 40% more likely to have anemia compared to the remaining children (Table 4).

Table 5 shows the variables that remained in the model of multiple analyses. After adjusting for variables at the same level and at lower levels, only age and family income remained associated to anemia.

DISCUSSION

The present study showd that a third of the children studied had anemia, and this condition was inversely associated to age and family income, which indicates a role of social inequalities in the development of anemia.

Similar prevalences were found in other population-based studies in Brazil[10,14] with same age children. Similarly, although other population-based studies found higher prevalences, they evidenced an inverse association with age and family income indicators as well.[11,13,15]

However, some studies[13-15] showed an association of other variables with anemia such as milk formula bottle feeding in the first years of life, crowding, gender, and sanitation conditions. In contrast, the present study found that all other exposures first associated to anemia lost their effect when adjusted for family income and age.

Even using sample estimate to determine the effect of an intervention (iron fortification of flour on the levels of hemoglobin) and without including the design effect correction, the study had 80% power to detect 1.5 risks or greater in all exposures studied.

The declining prevalence of anemia as age increases is a finding consistent with the literature, showing reduced prevalence starting from the third year of life. It can be that older children benefit from a greater variety of food choices. In the present study, children under three had the higher proportion of inadequate iron intake.

As mentioned before, compared to the children tested, those who did not have their hemoglobin measured (N=54; 10.7%) had significantly different characteristics regarding family income and parents' schooling. Bearing in mind that this bias could contribute for the overestimation of the overall prevalence of anemia in this population — as better-off children have less anemia — the prevalence corrected for refusals was estimated. However, it was 29.7%, similar to the crude prevalence of 30.2%. This was because the group with more losses, i.e., children with higher socioeconomic condition, comprised only 10.0 % of the study sample.

Differently from prior surveys in Brazil, the analyses in the present study included the design effect, estimated by dividing the estimated variance considering sampling by clusters by the estimated variance assuming a simple random sample. Thus, if the design by clusters (census tracts) were to produce changes, the design effect would be equal to one.[16]

The study design effect was 2.5 for the dichotomic variable (anemia), indicating intra-cluster homogeneity of risk. Given that clusters (census tract) are closely related to socioeconomic condition, the design effect reflects social differences for the development of anemia. Further surveys based on cluster sampling should take into account the need for increasing the sample size to compensate for the design effect and to properly correct estimates.

The analysis using Poisson regression, where results are expressed as prevalence ratios, was elucidative. This procedure is justified given the high prevalence of the outcome, which would yield odds ratios far greater than prevalence ratios if the analysis were conducted using logistic regression.[2]

It can be concluded that anemia was largely socially determined in the population studied. Interventions aiming at reducing anemia should be developed to lessen this condition in the short run targeting disadvantaged populations.

There still needs to explore whether iron-fortified flour will help to lower the prevalence of anemia in Brazil, and thus reduce the income effect on the development of this condition. Food fortification will be only successful if its effects are exerted on low-income children with remarkably high prevalence of anemia.

REFERENCES

1. Assis A, Barreto ML, Santos LMP, Sampaio LR, Magalhães LP, Prado, MS, Santos NS, Galvão NM, Silva RC, Oliveira VA. Condições de vida, saúde e nutrição na infância em Salvador. Salvador: Bureau, 2000.
2. Barros AJ, Hirakata VN. Alternatives for logistical regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol.* 2003;3(1):21.
3. Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-Based Interventions for Improving Perinatal and Neonatal Health Outcomes in Developing Countries: a review of the evidence. *Pediatrics.* 2005;115(2 Supl):519-617.
4. Greenland S, Rothman KJ. Introduction to stratified analysis. In: Rothman KJ, Greenland S, editores. Modern Epidemiology. Philadelphia: Lippincott Williams & Wilkins;1998. p. 253-79.
5. Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF. National Center for Health Statistics Growth Curves for Children birth-18 years. United States. *Vital Health Stat 11.* 1977;(165):i-iv, 1-74.
6. Institute of Medicine. National Academy of Sciences. Food and Nutrition Board. Dietary Reference Intakes (DRIs). Estimated Average Requeriments for groups. Washington; 2002.
7. Lima ACVMS, Lira PIC, Romani SAM, Eickmann SH, Piscoya MD, Lima MC. Fatores determinantes dos níveis de hemoglobina em crianças aos 12 meses de vida na Zona da Mata Meridional de Pernambuco. *Rev Bras Saude Matern Infant.* 2004;4(1):35-43.
8. Male C, Persson LA, Freeman V, Guerra A, Vann't Hof MA, Haschke F. Prevalence of iron deficiency in 12-mo-old infants from 11 European areas and influence of dietary factors on iron status (Euro-Growth Study). *Acta Pædiatr.* 2001;90(5):492-8.
9. Martins S, Logan S, Gilbert R. Iron therapy for improving psychomotor development and cognitive function in children under the age of three with iron deficiency anaemia. *The Cochrane Database of Systematic Reviews*. 2001;(2) Art. No.: CD000117. Disponível em: http://www.mrw.interscience.wiley.com/cochrane/clsysrev/articles/CD000117/frame.html
10. Monteiro CA, Szarfarc SC. Estudos das condições de saúde das crianças no município de São Paulo, SP (Brasil), 1984-1985. *Rev Saude Publica.* 1987;21(3):255-60.
11. Monteiro CA, Szarfarc SC, Mondini L. Tendência secular da anemia na infância na cidade de São Paulo (1984-1996). *Rev Saude Publica* 2000;34(Supl 6):62-72.
12. Mora JO, Mora LM. Deficiências de micronutrientes em América Latina y el Caribe: anemia ferropriva. Washington (DC): Organización Panamericana de la Salud; 1997.
13. Neuman NA, Tanaka OY, Szarfarc SC, Guimarães PRV, Victora CG. Prevalência e fatores de risco para anemia no Sul do Brasil. *Rev Saude Publica.* 2000;34(1):56-63.
14. Oliveira RS, Diniz AS, Benigna MJC, Miranda-Silva SM, Lola MM, Gonçalves MC, et al. Magnitude, distribuição espacial e tendência da anemia em pré-escolares da Paraíba. *Rev Saude Publica* 2002;36(1):26-32.
15. Osório MM, Lira PIC, Batista-Filho M, Ashworth A. Prevalence of anemia in children 6-59 months old in the state of Pernambuco, Brazil. *Rev Panam Salud Publica.* 2001;10(2):101-7.
16. Silva NN. Amostragem por Conglomerados. In: Silva NN. Amostragem Probabilística. São Paulo: Editora da Universidade de São Paulo; 2004. p. 75-91.
17. World Health Organization. Physical Status: the use and interpretation of anthropometry. Report of a WHO Expert Committee, Geneva; 1985. [WHO -Technical Report Series, 854]
18. World Health Organization. Iron deficiency anaemia. Assessment, prevention, and control. A guide for programme managers. Geneva; 2001.

Supported by the Ministry of Health/National Health Fund (Grant n. 2799/2003).