Child health and nutrition in the Western Brazilian Amazon: population-based surveys in two counties in Acre State

Saúde e nutrição infantil na Amazônia Ocidental Brasileira: inquéritos de base populacional em dois municípios acreanos

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Abstract

The article presents prevalence rates for malnutrition, intestinal parasitic infections, anemia, and iron deficiency in under-five children in a population-based cross-sectional survey performed in the urban area of two counties in the Western Brazilian Amazon, Assis Brasil (n = 200) and Acrelandia (n = 477). Available data included: (a) weight and height measurements, standardized as z-scores using the 1977 NCHS reference population, (b) diagnosis of current intestinal parasitic infection, (c) blood hemoglobin levels, and (d) plasma ferritin and soluble transferrin receptor levels. Overall prevalence rates of low weight-for-height, low weight-for-age, and low height-for-age were 3.7%, 8.7%, and 7.5%, respectively, with similar figures in the two towns. Intestinal parasites were detected in 32.5% children; helminths were uncommon. Anemia and iron deficiency were diagnosed in 30.6% and 43.5% of the children, respectively. Evidence of anemia was found in only 47.6% of the children with depleted iron reserves, indicating that hemoglobin measurement alone would severely underestimate the magnitude of iron deficiency in this population. In both towns, anemia and malnutrition were significantly more prevalent among children in the lowest socioeconomic stratum.

Iron-Deficiency Anemia; Anthropometry; Nutritional Status; Child Welfare

Introduction

Children under five years of age are particularly vulnerable to health problems and constitute a priority target for primary health care. Child health and nutrition are directly related to various factors that are amenable to prevention or modification, like food intake and exposure to various infections [1]. In developing countries, about 36% of under-five children presented low weight-for-age and 43% presented low height until the early 1990s [2], but there is evidence that these prevalence rates have decreased recently in various regions of the world [3]. The prevalence of iron deficiency anemia in the pediatric population in some developing countries can reach 50%, but there are few population-based studies available for comparison [4].

As in other developing countries [3], a significant improvement has been observed in child health in Brazil over recent decades, with a nationwide reduction in child mortality and malnutrition [5]. However, since the improvement has been less pronounced in the North and Northeast, preexisting inequalities have been exacerbated between these regions and the Center and South of Brazil [5,6]. The most recent available data on the prevalence of child malnutrition in Brazilian counties (or municipalities) are from the 1996 National Demographic and Health Survey (PNDS) [7]. Of the 212 under-five children examined in the North, 16.2% presented low height-for-age and 7.7% low weight-for-age [7]. This situation contrasts with that observed in the South and Southeast, where the prevalence of low height-for-age and low weight-for-age are about 3% and 6%, respectively [7].

Adequate planning of child nutrition programs in the North of Brazil requires the availability of recent data from population-based surveys, including information on growth deficits, but also on other nutritional deficiencies. For example, prevalence estimates are scarce for iron deficiency anemia in the Brazilian pediatric population, most of them resulting from the use of inadequate laboratory methods for estimating iron reserves [8]. There are no published data from population-based surveys concerning the prevalence of iron deficiency anemia in Amazonian pediatric populations.

We describe a comprehensive diagnosis of health and nutritional conditions in the pediatric population in two typical Amazonian counties, Acrelândia and Assis Brasil, which differ in terms of the basic economic development model adopted in recent years, but share socioeconomic indicators that are substantially lower than the national average. The county of Acrelândia originated from various nuclei in the Pedro Peixoto Directed Settlement Project, the largest agricultural settlement plan in the State of Acre, implemented by the National Institute for Rural Settlement and Agrarian Reform (INCRA) in the mid-1980s. Acrelândia is a frontier settlement whose adult population consists predominantly of migrants from the Southeast and South of Brazil. Meanwhile, Assis Brasil was incorporated as a county 30 years ago and is inhabited mostly by families from the area itself, working in extractive activities like rubber-tapping and Brazil nut gathering. Part of its territory is located in the Chico Mendes Extractive Reserve, the largest in the State.

Methodology

Study areas

The county of Acrelândia, incorporated in 1993, has a territory of 1,607.5km², situated between the Abunã and Iquiri (or Ituxi) rivers, in the Acre River Valley and bordering on Bolivia and the Brazilian States of Amazonas and Rondônia. In this area, described in detail in a previous publication [9], the University of São Paulo (USP) and the Federal University in Acre (UFAC) have conducted various collaborative surveys on urban and rural health and living conditions [10]. Acrelândia is located 112km east of Rio Branco, capital of the State of Acre, and has 8,697 inhabitants according to the Brazilian Institute of Geography and Statistics, or National Census Bureau (Instituto Brasileiro de Geografia e Estatística – IBGE) in 2003 [11], 43% of whom in urban areas. The Human Development Index (HDI) was estimated in 2000 at 0.680, with an infant mortality rate of 70.75 per thousand live births. The functional illiteracy and illiteracy rates are 50.9% and 26.7%, respectively [12,13]. The main economic activity is commercial agriculture.

Assis Brasil, incorporated in 1976, has a population of 3,667 (IBGE estimate for 2003 [9]), 62% in the urban area. Assis Brasil has a territory of 2,884.2km², located on the border with Bolivia and Peru and the counties of Brasiléia and Sena Madureira in Acre State, and is located 344km southwest of Rio Branco. The overall HDI in 2000 was 0.670, with an infant mortality rate of 67.4 per thousand live births. The functional illiteracy and illiteracy rates are 51.3% and 29%, respectively [12,13]. The main economic activities are cattle raising and timbering, with an insignificant agricultural crop output.

Study population, data collection, and ethical aspects

We conducted a cross-sectional study of the entire population under five years of age residing in the urban area of Acrelândia and Assis Brasil. Data and samples (interviews, anthropometry, and blood and stool samples for laboratory tests) were collected from January 14 to 31, 2003, during the rainy season of the Western Amazon. All 491 households were visited (334 in Acrelândia and 157 in Assis Brasil) in which the total of 724 under-five children lived, according to records from the Family Health Program, updated in December 2002. The fieldwork was done with the participation of community health agents, nursing students from UFAC, and university-level health professionals with training and local supervision by the project research team. During the home visits, the interviewers introduced themselves, explained the survey's objectives and benefits, and asked the parents or guardians to sign a free informed consent form, ensuring them of the confidentiality of the resulting information and feedback with the individual results of laboratory tests. The study was reviewed and approved by the Institutional Review Board of the School of Public Health, University of São Paulo (USP research protocol nº. 810).

Description of socioeconomic conditions and disease history

During the fieldwork, two supervisors distributed the structured questionnaires to the interviewers, to be applied to the children's parents or guardians in home interviews in order to obtain data on socioeconomic and environmental variables. The target variables were: (a) demographic (child's gender and age); (b) socioeconomic (presence of home appliances and consumer goods in the household, paternal schooling, presence of the father in the household, maternal work, number of members currently living in the household), and environmental (connection to the public sewage system and water supply, garbage collection); (c) reproductive (maternal age, gestational age and birth weight); (d) nutritional (total and exclusive breastfeeding and weaning foods); (e) past morbidity (diarrhea, cough, or fever in the 15 days prior to the home visit, bouts of malaria in the previous 12 months, hospitalization of the child and wheezing in the previous 12 months).

Anthropometric evaluation

A single observer (T.G.C.) measured the child's weight and stature, and the mean of two separate measurements was used for the data analysis. Children two years or older were weighed with a portable electronic digital scale (Plenna, USA), with a capacity of 150kg and accurate to 100g. Children under two years of age were weighed using a digital pediatric scale with a capacity of 16kg and accurate to 10g (Soehnle, Germany). Children two years or older were measured with a stadiometer, accurate to 0.1cm, attached to a flat surface on a wall without a baseboard and perpendicular to the floor. The children were positioned barefoot in the vertical standing position in the middle of the stadiometer, with the head, shoulders, buttocks, and heels leaning against the wall. Children under two years of age were measured with an infant anthropometer, accurate to 0.1cm. This measurement required two observers (P.T.M. and T.G.C.), placing the child in the supine position on the anthropometer, set on a table. The child's head was placed vertically and in contact with the upper base of the equipment, with the legs extended. Weight-for-age (W/A), weight-for-height (W/H), and height-for-age (H/A) were calculated as z-scores, using Epi Info version 6.01 (Centers for Disease Control and Prevention, Atlanta, USA), based on the reference population of the National Center for Health Statistics (NCHS) for 1977 [14]. Children were defined as malnourished with W/A, W/H, or H/A less than or equal to -2 z-scores. Children were defined as overweight with W/H greater than or equal to +2 z-scores. Parents of children with abnormal nutritional parameters were oriented to take them to the local unit of the Family Health Program.

Diagnosis of intestinal parasites

A stool sample was requested from all the study subjects at the time of the interview, for subsequent analysis, and Coprotest® cups containing a preservative solution (10% formalin) were provided for this purpose. The stool samples were examined as described by Hoffman et al. [15], in laboratories installed in the two counties. The parasitological diagnostic method used is appropriate for detecting the eggs and cysts of most human intestinal parasites, except for *Cryptosporidium parvum, Cryptosporidium hominis*, and *Cyclospora cayetanensis* cysts, *Enterobius vermicularis* eggs, and *Strongyloides stercoralis* larvae. The maximum time elapsed between collecting and processing stool samples was two weeks. Individuals with intestinal parasitic infections received free treatment [16], prescribed by the project's medical team.

Diagnosis of anemia and iron deficiency

Venous blood samples, drawn after 10-12 hours of fasting, were used to measure blood hemoglobin with a Hemocue portable hemoglobinometer (Ängelhom, Sweden). Anemia was defined as values below the cutoff point of 11.0g/100ml of blood, set by the World Health Organization (WHO) [17]. Body iron status were assessed in two stages. Initially the plasma ferritin levels were determined, and iron deficiency was defined as less than 12μg/L [17]. In children with plasma ferritin levels above the stipulated cutoff point, a second test was used: determination of plasma soluble transferrin levels. This strategy aimed to diagnose iron deficiency in children with inflammatory or infectious processes, which tend to increase the ferritin levels without altering the soluble transferrin levels [17]. Both were measured using enzyme-linked immunosorbent assay (ELISA) with commercially available reagents (Ramco Laboratories, Stafford, USA). Since there is no consensus as to the cutoff for diagnosis of iron deficiency based on plasma soluble transferrin levels [17], the cutoff suggested by the kit manufacturer was used (8.3mg/L). Children with anemia diagnosed during the study received free treatment with ferrous sulfate (2mg of iron per kg body weight for children under two years of age and 4mg of iron per kg weight for other ages), prescribed by the research project's medical team.

Data processing and analysis

The collected data were keyed in and analyzed using SPSS PC+ version 12.0 (SPSS Inc., Chicago, USA). Relative and absolute frequency distributions, medians, means, and standard deviations of the variables were calculated. Statistical analysis used the Student t test for independent samples and the chi-square for comparison of means and proportions, respectively. Statistical significance was set at $p < 0.05$.

The families' socioeconomic status was evaluated by calculating a wealth index based on the presence of consumer goods and home appliances in the household [18]. The family income variable was not used in this analysis because it is difficult information to obtain and provides an imprecise reflection of household socioeconomic status [18]. The family wealth index was obtained by principal components analysis using XLSTAT software, version 7.5.2 (Addinsoft, New York, USA). The first principal component, which explained 32.7% of the variation among families, was used to derive weights (in parentheses) for each asset present in the household: television set (0.264), stereo system (0.280), VCR (0.135), stove (0.200), refrigerator (0.311), radio (0.203), telephone (0.278), blender (0.345), bicycle (0.217), electric iron (0.307), motor vehicle (0.161), sofa (0.312), washing machine (0.327), and satellite antenna (0.295). After standardizing the weights assigned to the consumer items, the highest (positive) scores were associated with the presence of a motor vehicle (2.835), VCR (2.865), telephone (1.350), radio (1.242), satellite antenna (1.161), and sofa (1.039), and the lowest (negative) scores with the absence of a stove (-4.141), refrigerator (-1.876), television set (-1.833), bicycle (-1.446), blender (-1.303), washing machine (-1.292), stereo system (-1.060), and electric iron (-1.275) in the household. The scores were all added to produce an estimated index of household wealth, which was then categorized in quartiles. Prevalence rates for nutritional disorders were analyzed according to wealth index quartile.

Results

Demographic, socioeconomic, and environmental characteristics

Of the 724 children identified in the household survey, 720 (99.4%) were interviewed; only four children were not interviewed because their parents or guardians refused to provide consent. In all, the sample population included 677 subjects who completed the physical and clinical examination (93.5% of the eligible individuals). In Assis Brasil, the mean age of the study population was 29.5 (SD 16.9) months, and 48% of the children were males. In Acrelândia, the mean age was 31.42 (SD 16.9) months, with 49.5% males. The majority of families in both counties did not own their land; there were significantly more landowners in Assis Brasil (27.5%) than in Acrelândia (18.4%) ($p = 0.027$).

Table 1 shows the sample population's demographic characteristics and household socioeconomic and environmental variables for the two counties. Although paternal schooling was lower in Acrelândia, mean schooling was low in both counties (7.1 years in Assis Brasil and 6.2 years in Acrelândia; Student t test, $p < 0.05$). In both counties the majority of the households had toilets, but few households were connected to the public sewage system (3% in Assis Brasil and 1.5% in Acrelândia), and human waste was generally dumped into septic tanks or sewage tanks. Acrelândia had lower proportions of households with running water and sewage connections. The majority of households in both counties disposed of garbage adequately (garbage collection, public dumpsters, or garbage buried or burned).

Reproductive, birth weight, and breastfeeding characteristics

In both counties, the majority of mothers worked at home, with a higher proportion of mothers who worked outside the home in Assis Brasil (23%) than in Acrelândia (11.7%) ($p = 0.023$). The reported prematurity rate was low: 2.5% in Assis Brasil and 2.7% in Acrelândia. The prevalence of low birth weight (< 2,500g), based on information from the children's health cards, was higher in Acrelândia (9.6%) than in Assis Brasil (4.5%) ($p = 0.025$). Mean maternal age (SD) was similar in the two counties: 26.3 years (SD 7.5) in Assis Brasil and 27.1 years (SD 8.9) in Acrelândia.

In the entire study population, 94.1% of infants (n = 634) started breastfeeding, with no statistically significant difference between the two counties (92% in Assis Brasil and 94.7% in Acrelândia). Overall, 30% of infants showed exclusive breastfeeding up to six months (not including those who never breastfed). Nine percent of children (n = 43) breastfed for at least two years, and there was a median of 180 days of total breastfeeding.

Nutritional status

The overall nutritional deficiency prevalence rates according to the W/H, W/A, and H/A indices were 3.7%, 8.7%, and 7.5%, respectively. The

Table 1

Frequency distribution of demographic, socioeconomic, and environmental variables in two counties of Acre State, Brazil, 2003.

Socioeconomic variables	Assis Brasil (n = 200)		Acrelândia (n = 477)	
	n	%	n	%
Gender				
Male	96	48.0	236	49.8
Female	104	52.0	238	50.2
Age bracket (months) *				
0-5	20	10.0	53	11.2
6-11	42	21.0	85	17.9
12-23	43	21.5	101	21.3
24-59	95	47.5	235	49.6
Inhabitants per household **				
≤ 3	33	16.6	54	11.6
4-6	108	54.3	299	64.3
7-10	58	29.1	112	24.1
Paternal schooling (years) **				
None	15	8.2	47	11.4
1-4	50	27.5	157	38.1
5-8	39	21.4	128	31.1
> 8	78	42.9	80	19.4
Drinking water **				
Public water supply	154	77.0	254	53.2
Artesian well	42	21.0	216	46.8
Garbage				
Public garbage collection	178	89.0	364	76.3
Sewage disposal				
Septic tank	138	69.7	360	76.9

* In Acrelândia, n = 474, since the birth dates were not available for three children;

** Comparison of the two counties using the χ^2 test, $p < 0.05$.

prevalence of W/H and H/A deficits increased significantly with age beginning at 12 months (χ^2 test for trend, $p < 0.001$). No statistically significant differences were observed between counties in malnutrition prevalence rates ($\chi^2 = 0.45$, $p = 0.50$; $\chi^2 = 0.07$, $p = 0.79$; $\chi^2 = 0.28$, $p = 0.59$, respectively for W/A, W/H, and H/A) or overweight ($\chi^2 = 0.16$, $p = 0.70$). Overall overweight prevalence according to the W/H index was 2.8%, with no statistically significant difference by gender. However, overweight prevalence tended to decrease with age ($\chi^2 = 6.05$, $p = 0.014$), with the highest prevalence of overweight in the 12 to 24-month age group (7%).

We measured hemoglobin concentration in 669 children (92.4% of the eligible children and 98.8% of those interviewed and examined) and plasma ferritin in 628 (86.7% of the eligible children and 92.8% of those interviewed and examined). Plasma transferrin receptor levels were measured in the 326 children who presented normal or elevated plasma ferritin. Based on hemoglobin levels, 205 children (30.6%) were classified as anemic. Based on the combined analysis of plasma ferritin and transferrin receptor levels, 273 children (43.5%) were classified as iron deficient. Combining the results for hemoglobin, ferritin, and soluble transferrin receptor, 130 children (20.9%) were diagnosed with iron deficiency anemia. There were no statistically significant differences in the prevalence rates for anemia, iron deficiency, and iron deficiency anemia according to gender or county. In all, 68.1% of the anemic children presented iron deficiency, while the remaining cases of anemia were attributed to other nutritional deficiencies or various other etiological factors. Only 47.6% of the children with iron deficiency presented anemia, highlighting the low sensitivity of hemoglobin measurement to diagnose iron deficiency at the population level.

Statistically significant differences were observed in the anemia, iron deficiency, and iron deficiency anemia rates according to age; the highest prevalence rates for anemia (50.2%), iron deficiency (62%), and iron deficiency anemia (38.9%) were observed in children under 24 months of age, as compared to the other age groups (χ^2 test, $p < 0.0001$).

Table 2 shows the frequency of nutritional deficits in each municipality. There were no statistically significant differences between counties in the prevalence rates for malnutrition or obesity. However, the prevalence rates for anemia and iron deficiency anemia were significantly higher in Assis Brasil.

Table 2

Frequency distribution of nutritional deficiencies based on low W/A (weight/age), H/A (height/age), W/H (weight/height), overweight according to high W/H, iron deficiency, and iron deficiency anemia in two counties of Acre State, Brazil, 2003.

Nutritional disorders	Assis Brasil (n = 200)		Acrelândia (n = 477)	
	n	%	n	%
Malnutrition *				
W/A index	15	7.5	44	9.3
H/A index	13	6.5	37	7.8
W/H index	8	4.0	17	3.6
Overweight **	4	2.0	15	3.2
Anemia ***	70	36.3	135	24.5 ###
Iron deficiency #	85	45.2	188	42.7
Iron deficiency anemia ##	48	26.4	82	18.7 ###

* Two or more standard deviations below the standard median of the National Center for Health Statistics [14]; n = 474 in Acrelândia;
** Two or more standard deviations above the standard median of the National Center for Health Statistics [14]; n = 474 in Acrelândia;
*** Blood hemoglobin less than 11g/dL;
# Plasma ferritin < 12μg/L or transferrin receptor > 8.3mg/L;
Blood hemoglobin less than 11g/dL and plasma ferritin < 12μg/L or transferrin receptor > 8.3 mg/L;
χ^2 test, $p < 0.05$.

Table 3

Frequency distribution of intestinal parasitic infections and reported diseases in two counties of Acre State, Brazil, 2003.

Disease	Assis Brasil (n = 200)		Acrelândia (n = 477)	
	n	%	n	%
Intestinal parasites	51	31.7	127	32.4
Diarrhea in the previous 15 days	69	34.5	129	27.2
Any lifetime hospitalization *	38	19.0	131	27.5
Cough or fever in the previous 15 days	77	38.5	157	33.3
Wheezing the previous 12 months	43	21.5	93	19.7

* χ^2 test, $p < 0.05$.

Reported diseases and intestinal parasites

Of the 554 children who had stool samples obtained and examined (76.5% of the eligible children and 81.8% of those interviewed and examined), 180 (32.5%) harbored one or more intestinal protozoa or helminths detected by the parasitological method used in the study. No statistically significant difference was observed in the prevalence of intestinal parasites comparing boys (26.6%) and girls (27.5%) or children from Assis Brasil (31.7%) and Acrelândia (32.4%).

The most common infections involved the protozoan parasite *Giardia duodenalis* (18% in Assis Brasil, n = 29; and 27.7% in Acrelândia, n = 109), the commensal protozoan *Entamoeba coli* (6.2% in Assis Brasil, n = 10; and 5.1% in Acrelândia, n = 20), and the helminth *Ascaris lumbricoides* (9.9% in Assis Brasil, n = 16; but only 0.2% in Acrelândia, n = 1). Multiple parasite infections (simultaneous infection with two or more species of intestinal parasites or commensals) were observed in 6.8% of the children examined in Assis Brasil and 4.1% of those in Acrelândia. Combining the data from the two counties, the prevalence of intestinal parasites increased significantly with age (χ^2 test for trend, $p < 0.00001$).

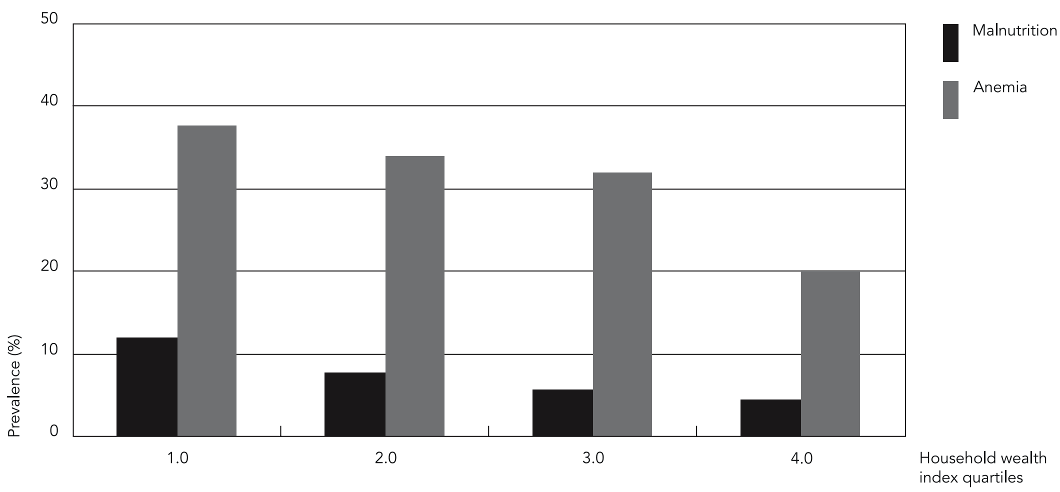
Table 3 shows the prevalence distribution of intestinal parasites and reported disease events in the two counties. There were a higher proportion of children with a history of hospitalization in Acrelândia than in Assis Brasil, but no statistically significant differences were seen between the counties in the prevalence of other reported disease events. Only six children (1.2%) in Acrelândia (and one in Assis Brasil) had one or more episodes of malaria diagnosed in the 12 months prior to the survey.

Prevalence of malnutrition and anemia according to household wealth index

Figure 1 shows the association between the wealth index and the overall malnutrition prevalence rates according to the H/A index and anemia in the combined pediatric population of Assis Brasil and Acrelândia (n = 674). There was a statistically significant inverse association between prevalence of both malnutrition and anemia and household wealth index (χ^2 test for trend, $p = 0.006$ and $p = 0.0005$, respectively). No

Figure 1

Prevalence of malnutrition according to the H/A index and anemia in the pediatric population of Assis Brasil and Acrelândia according to household wealth index quartiles. Acre State, Brazil, 2003 (n = 674).



Statistically significant inverse association between prevalence of malnutrition/anemia and household wealth index: χ^2 tendency test, p = 0.006 and p = 0.0005, respectively.

association was observed between household wealth index and intestinal parasites prevalence.

Discussion

Although Acrelândia and Assis Brasil are examples of Amazonian counties with distinct economic activities, they show very similar childhood health indicators. The results of this study only showed significant differences between the counties in the prevalence rates for anemia and iron deficiency anemia, which were more common in Assis Brasil than in Acrelândia (Table 2). In both counties, the prevalence of growth deficit (according to the height-for-age index) was nearly 50% lower than that observed in 212 children from the North of Brazil examined during the PNDS in 1996 (16.2%) [7]. The prevalence of low weight-for-age in both counties (8.7%) was similar to that observed in the PNDS (7.7%), while the prevalence of low weight-for-height in Assis Brasil and Acrelândia (3.7%) was three times higher than the PNDS figure for the North of Brazil (1.2%) [7]. Surprisingly, the prevalence of low weight-for-height in children from the North examined by the PNDS was the second lowest in Brazil, slightly more than half the national average of 2.3% [7]. Since no time series are available for analysis, it is not known whether the discrepancies between the estimates in our study and those of the PNDS are due to spatial heterogeneities in the Northern Region or simply reflect a trend towards preferential improvement in some child health and nutrition indicators over the course of the last decade

The lack of prevalence estimates for iron deficiency anemia in Brazilian pediatric populations makes comparisons difficult. Most available studies are based on convenience samples (health services users, for example), submitted exclusively to hemoglobin testing [8], failing to provide data on body iron status [19]. The current study provides the first estimates derived from population-based surveys of the prevalence of iron deficiency anemia in children from the Brazilian Amazon. Two results are particularly relevant for the prevention and control of anemia in this population: (a) only 47.6% of the children with iron deficiency had anemia, indicating that measuring hemoglobin alone underestimates the magnitude of iron deficiency in this population by more than 50% and (b) 31.9% of anemic children had no biochemical evidence of iron deficiency, suggesting the role of other determinants of anemia (nutritional, biochemical, or infectious) in this population.

The proportion of anemic children in our sample (30.6%) was similar to that found in preschoolers in Paraíba State (36.4%) [20], but lower than observed in the same age bracket in recent population-based surveys in the State of Pernambuco (40.9%) [21] and in counties of São Paulo State (46.9%) [22], Criciúma, Santa Catarina State (54%) [23], and Porto Alegre, Rio Grande do Sul State (47.8%) [24]. The available data suggest that the highest pediatric anemia prevalence rates occur in urban areas of the most developed regions of the country. However, some factors limit the validity of these comparisons: (a) several estimates are from studies with blood samples drawn by finger-prick, a procedure that can dilute the sample and introduce a systematic error into hemoglobin measurement [25] and (b) the relative weight of other causes (nutritional and non-nutritional) of anemia other than iron deficiency can differ between regions. In fact, WHO does not recommend using blood hemoglobin alone as the screening test for iron deficiency [17]. Its low sensitivity is due to the fact that large depletions of body iron reserves are necessary to affect the hemoglobin concentration. Its low specificity is due to the existence of other causes of anemia with high prevalence in certain populations, like other nutritional deficiencies, infections, glucose-6-phosphate dehydrogenase (G6PD) deficiency, and various hemoglobinopathies [19].

The determinants of iron deficiency in children include maternal anemia, low birth weight, prematurity [26], parasitic infection [27], chronic or recurrent infections, short duration of breastfeeding and the introduction of inadequate weaning diets [28], and the low quality and bioavailability of the iron contained in the diet [29]. The deficiency of other micronutrients not evaluated in this study, like vitamin B12, folic acid, and vitamin A, is another important determinant of nutritional anemia. According to a recent study in the State of Pernambuco with children 6 to 60 months of age, serum vitamin A concentration was one of the factors associated with blood hemoglobin levels [21].

The low prevalence of helminth infections may be partially explained by periodic deworming with medication, widely distributed by the community health agents in the Family Health Program in both counties. It is unlikely that the fact that a single stool sample was examined greatly underestimated the prevalence of helminth infections with greater clinical impact in the region [30]. The lack of a significant association between helminth infection and anemia or growth deficits in our population (data not shown) is not surprising, given the low prevalence of helminth infections capable of causing significant nutrient depletion, such as *Ascaris*, *Trichuris*, and hookworms [27]. However, intestinal protozoan infections were much more prevalent in Acrelândia and Assis Brasil than among under-five children in the municipality of São Paulo who were studied in 1995 and 1996 [31], and may contribute to the high prevalence of recent diarrheal disease reported in our sample population (Table 3).

A significant inverse association was observed in Acrelândia and Assis Brasil between household wealth and anemia and malnutrition (but not intestinal parasites). Previous studies also showed an association between socioeconomic conditions and nutritional status in children from various regions of Brazil, both in cross-sectional surveys and temporal series analyses. For example, Monteiro et al. [32] observed a lower reduction in the prevalence of child malnutrition in Brazil (from 1975 to 1989) in the lowest per capita income stratum (the poorest 25%) as compared to the highest stratum (the wealthiest 25%). In the municipality of São Paulo, an increase was observed in the prevalence of anemia in all economic strata among under-five children from 1984 to 1996; however, this trend was more unfavorable among children from the poorest families [22]. Studies in Porto Alegre and Criciúma showed similar results in children less than three years of age, with a higher prevalence of anemia in poorer children [23,24].

Access to clean water and sewage treatment is one of the main determinants of child health and nutrition [33]. The trend in child malnutrition in Brazil from 1975 to 1989 indicates that the observed improvements are associated with increased coverage in sanitation, health, and educational services, as well as in the supply of food supplementation programs. However, the regions with the highest prevalence of child malnutrition in 1975 (the North and Northeast) were the same ones that least benefited from these services and programs, thus increasing the gap between them and the rest of the country [32]. In the two counties of Acre State studied here, the low coverage of basic sanitation poses a serious obstacle to subsequent improvement of child health indicators.

The prevalence of low birth weight in Acrelândia (9.6%), resulting from prematurity or intrauterine malnutrition, is within the range found in Latin American countries (6.3-12.5%) [34]. It is close to the prevalence rates observed in the city of São Paulo in 1998 (8.9%) [35] and Pelotas, Rio Grande do Sul State, in 2005 (10.4%) [36]. Assis Brasil showed a low prevalence rate for low weight birth weight (4.5%), close to that observed in developed countries [34].

Most mothers in Acrelândia and Assis Brasil initiated breastfeeding, but the median duration of total breastfeeding was low (three months), lower than that reported for the overall Brazilian population (seven months) [37]. However, the prevalence of exclusive breastfeeding up to six months (30%) was higher than observed by Longo et al. [38] in children using health services in 12 Brazilian State capitals (with an 8% prevalence of exclusive breastfeeding up to four months of age). Duration of breastfeeding and adequate complementary diet are important upstream determinants of adequate child nutritional status, reducing the risk of malnutrition [39] and iron deficiency anemia [40].

The Millennium Development Goals for developing countries [41] approved in a special session of the United Nations General Assembly include a reduction by at least one third in the prevalence of malnutrition in under-five children, with a special focus on children less than two years of age, by the year 2015 [42]. The Brazilian National Food and Nutrition Policy also specifies the country's social commitment to reduce the prevalence of iron deficiency anemia [43]. However a recent UNICEF (United Nations Children's Fund) report [44] shows an extremely unfavorable scenario for Amazonian children, 40% of whom are from low-income families and 53% of whom live in communities without adequate basic sanitation, frequently in makeshift housing. The report on the Brazilian health situation entitled *Saúde Brasil 2004: Uma Análise da Situação de Saúde* [45], estimates the infant mortality rate in the State of Acre at 34.3 per thousand live births in the year 2001, substantially higher than the national average (27.7 per thousand). In 2000, only 34% of Acre's population had access to the public water supply, 52% to garbage collection, and 28.7% to the public sewage system or septic tanks; all of these indicators are below the national averages. The child development index in Acre is the second worst in the country [46].

The economic and social disparities between the North/Northeast and Center/South of Brazil indicate the need for adequate implementation of nationwide public policies to minimize the impact of such inequalities on child growth and development. Health diagnoses derived from population-based studies, as that presented here, are fundamental for planning interventions to change this reality.

Resumo

As prevalências de desnutrição, parasitoses intestinais, anemia e deficiência de ferro foram avaliadas, por meio de inquéritos transversais de base populacional, em pré-escolares na área urbana de dois municípios das Amazônia Ocidental Brasileira, Assis Brasil (n = 200) e Acrelândia (n = 477). Os índices antropométricos peso/estatura (P/E), peso/idade (P/I) e estatura/idade (E/I) foram calculados como escores z, com base na população de referência do National Center for Health Statistics de 1977. Diagnosticaram-se déficits nutricionais segundo índices P/E, P/I e E/I em 3,7%, 8,7% e 7,5% das crianças, respectivamente. Encontraram-se parasitas intestinais em 32,5% das 554 amostras examinadas, sendo raras as infecções por helmintos. Com base nos níveis de hemoglobina sangüínea e níveis plasmáticos de ferritina e receptor solúvel de transferrina, diagnosticaram-se anemia e deficiência de ferro em 30,6% e 43,5% das crianças, respectivamente. Somente 47,6% das crianças com deficiência de ferro tinham anemia, indicando que a medida isolada de hemoglobina sangüínea subestima a magnitude da deficiência de ferro nesta população. Nos dois municípios, a anemia e a desnutrição foram significantemente mais prevalentes entre as crianças de famílias dos estratos sócio-econômicos mais baixos.

Anemia Ferropriva; Antropometria; Estado Nutricional; Saúde Infantil

Contributors

P. T. Muniz and M. A. Cardoso designed the research project and obtained funds to implement it. P. T. Muniz coordinated the fieldwork and initial data processing. T. G. Castro participated in the training and supervision of the anthropometry during the fieldwork. T. S. Araújo and N. B. Nunes participated in the supervision of the fieldwork and keying-in and initial processing of the data. M. Da Silva-Nunes, E. H. E. Hoffmann, and M. U. Ferreira processed and analyzed the laboratory samples. T. G. Castro and M. A. Cardoso analyzed the data. T. G. Castro, M. U. Ferreira, and M. A. Cardoso drafted the manuscript, which was read and approved by all the authors.

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