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Giardia lamblia AND OTHER INTESTINAL PARASITIC INFECTIONS AND THEIR RELATIONSHIPS WITH NUTRITIONAL STATUS IN CHILDREN IN BRAZILIAN AMAZON

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SUMMARY

The objective of this survey was to assess the relationships between intestinal parasitism, nutritional status and hemoglobin level in children with Indian ascendancy living in an urban area in Brazilian Amazon. We carried out a cross-sectional survey obtaining anthropometric, parasitological and socioeconomic data, and hemoglobin measurements of children aged six to 84 months. Anthropometric data were expressed as z-scores for weight for age (WAZ), height for age (HAZ), weight for height (WHZ) and mid upper circumference for age (MUACZ) parameters. Parasitological examinations were performed through Ritchie (n = 307), Kato-Katz (n = 278), Baermann-Moraes (n = 238) and Safranin-methylene blue methods (n = 307). Hemoglobin measurements were obtained with a Hemocue® photometer (n = 282). Socioeconomic data were used in order to classify children in three family income strata (n = 242). Multiple linear regression analysis showed independent interactions between *Giardia lamblia* and WAZ (beta = -0.195, SE = 0.138, p = 0.003), WHZ (beta = -0.161, SE = 0.133, p = 0.018) and MUACZ (beta = -0.197, SE = 0.143, p = 0.011), controlling for age, sex, family income, *Ascaris lumbricoides,* and hookworm infection. Also, the multivariate model showed that the only variable associated with hemoglobin levels was age. Intestinal parasitism control should increase children's possibilities of full development in the studied area.

KEYWORDS: *Giardia lamblia*; Intestinal Parasitism; Nutritional Status; Hemoglobin; Children; Brazilian Amazon; Indians.

INTRODUCTION

Enteric parasitic diseases lie among the many health problems observed in economically disadvantaged populations of the poorest countries.

Intestinal parasitism has clear social and environmental determinants, with high prevalence in regions with deficiency in sanitation, potable water supplies, education and adequate dwelling conditions. The burden attributed to intestinal parasites has been studied in three domains: growth and ponderous gain deficits, iron deficiency anemia and disturbances of cognitive function[4,21].

The associations between malnutrition and intestinal parasitism has been demonstrated in cross-sectional surveys involving the correlation between nutritional status and both prevalence and intensity of infections[7,12,13,17,18,20]. Those conditions may cause damage to full individual development, affecting even cognitive function and school performance of children[4,15].

Also, acute complications may occur, often severe and potentially fatal, such as intestinal obstruction, severe anemia and rectal prolapse[5], observed mainly in infections by high worm burdens, afforded by high levels of exposition observed in the absence of adequate conditions of sanitation and excreta destination.

Undernutrition still represents an important public health problem, mainly in the developing world. Prevalence of chronic malnutrition in children reaches 12.6% in Latin America, 34.4% in Asia, 35.2% in Africa and 32.5% in all developing countries[16].

The World Health Organization (WHO) estimates that near two billion people in the world have iron deficiency anemia, characterizing the deficiency of this micronutrient as the commonest on a global scale[24]. The groups most affected in developing countries are school-aged children and pregnant women, with an estimated prevalence of 53% in both cases[24].

The Brazilian Amazon, localized mainly in the North Region, encompasses the majority of national Indian communities. Children's malnutrition in these populations has been described. Contact with national society and abandonment of ancestral practices like hunting and gathering, besides subsistence monoculture agriculture have been related to qualitative and quantitative deterioration of both diet and

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nutritional status observed in that societies[19]. In Brazil, the most recent survey at national level for children nutritional status was carried out in 1996. It estimated stunting prevalence of 16.2%, 17.9%, 5.1% and 10.5%; and underweight frequencies of 7.7%, 8.3%, 2% and 5.7% in the North, Northeast, South and whole national territory respectively[3]. This shows an important regional variability and suggests that populations living in Amazon have a worst nutritional status when compared with those living in other Brazilian regions.

Urbanization carried out without sanitary and housing infrastructure has been observed in Brazilian Amazon, often producing disease by creation of socioeconomic and environmental conditions to its spread. It's the case of intestinal parasitism and other infectious diseases like tuberculosis, leprae, dengue, leishmaniasis and malaria.

The objective of the present survey was to identify the relationships between intestinal parasitism and nutritional status, including hemoglobin levels, of children with Indian ascendancy living in Santa Isabel do Rio Negro, an urban area in Brazilian Amazon.

METHODS

Setting: The study was performed in Santa Isabel do Rio Negro, a municipality situated in the northwest of Amazonas State (0º 28' S and 65º 32' W), distant 781 km from Manaus, the State capital, by fluvial route, in the Alto Rio Negro Region. The majority of the population has Amerindian ancestry. The whole municipality has 10,561 inhabitants. In the heart live 4,220 people (720 children aged six to 84 months), distributed in 773 dwellings and six districts[8]. The remaining population is distributed in hundreds of small communities in the backlands of the municipality. Inhabitants of the municipality heart descend from Tukano Oriental (which includes Tukano, Pira-tapuya and Desana groups) and Aruak (Baniwa, Bare and Tariana groups) speaking societies[9]. At present, interethnic marriage is very frequent; the existence of individuals with parents belonging to different groups being common, mainly in the urban area. Sanitary infrastructure is markedly deficient. This study involved the urban population, living in the municipality seat.

Strategy for children recruitment and sampling: Children included in this survey are attended by the non-governmental organization "*Pastoral da Criança*". This entity belongs to the Brazilian Catholic Church and performs monthly weight measurements of children aged six to 84 months in the heart of the municipality. We carried out meetings with "*Pastoral da Criança*" local leaderships in order to explain the protocol and objectives of the project. The research team stayed two days in each of the six districts in the city, performing anthropometry and hemoglobin measurements in the Community Centers, with the supervision of "Pastoral da Criança" staff of each district, aiming to cover the entire municipality's seat. The whole population aged six to 84 months (720 children) was invited to participate in the study, but three hundred seven children, (near 42.6% of the entire population in this age group living in the heart of the municipality) attended the Community Centers during the survey period.

Subjects were included after their parents gave informed consent. The Human Subject Ethics Committee at Evandro Chagas Research Institute of Oswaldo Cruz Foundation previously approved the research.

Study design and statistical analysis: This cross sectional survey was carried out from 8th to 25th August 2005. Investigators provided plastic fecal collectors without preservatives to the parents and performed anthropometry and hemoglobin measurements. A questionnaire with demographic and socioeconomic information was filled in an interview with children's parents, in order to classify the families in three different socioeconomic strata. These strata where defined by monthly family income. The first was constituted by families receiving more than 266 United States Dollars (USD), corresponding to two Brazilian "minimum wages", the second included families with an income from 133 to 266 USD (one to two Brazilian minimum wages) and the thirst was composed by families with activities that did not involve wages (farmers who practice familiar agriculture). In bivariate analysis, the dependent variables were the anthropometric parameters and hemoglobin level, while independent variables were the intestinal parasitic infections. Means were compared through analysis of variance (ANOVA) and frequencies by the chi-square test. In multivariate analysis, the linear regression model included as independent variables age, socioeconomic status and selected parasitic infections, based on the influence of each one observed on the bivariate analysis. Statistical analyses were performed using the SPSS 9.0 software.

Collection and processing of stool samples: Children's parents were encouraged to return the fecal sample to the field laboratory assembled in the local health unity. Twenty-nine samples had not enough material, so Kato-Katz smears of 278 children were performed in this laboratory. Sixty-nine samples had not enough material to perform the Baermann-Moraes technique, so 238 examinations were made through this method, with fresh stools, in the field laboratory. After these examinations, a preservative (SAF, sodium acetate-acetic-formalin) was added to the stool sample, in order to perform the Ritchie and safranin-methylene blue methods (n = 307). All children older than 24 months with a positive examination on Kato-Katz received a single dose of Albendazole and those aged 12 to 24 months received a three-day Mebendazole treatment.

Anthropometric and hemoglobin measurements: Body weight was recorded with a portable electronic scale, to the nearest 100g. Subjects were barefoot and wore minimum clothing. Infants aged less than 12 months were weighted in their mothers' arms. Height or length was measured using an anthropometer to the nearest 0.1 cm. Mid upper-arm circumference was measured with a flexible tape on the left arm, at the midpoint between the acromium and the olecranum. A single person performed all measurements.

Z-scores (standard deviations) from the National Centers for Health Statistics (NCHS) reference values[25] of height for age (HAZ), weight for height (WHZ), weight for age (WAZ) and mid upper arm circumference for age (MUACZ) were calculated using the NutStat Module on EpiInfo 2000 version 3.2.2. Stunting, wasting and underweight were defined by values equal or below -2 for HAZ, WHZ and WAZ respectively[23]. Severe stunting was defined by a value below -3 for HAZ.

Hemoglobin (Hb) was analyzed using a Hemocue Photometer. Anemia was defined by Hb values below 11 mg/dL for children aged 6 to 60 months and below 11.5 mg/dL for children aged up to 60 months[24]. All ages were obtained from immunization certificates. Anemic children received ferrous sulphate (5 mg/kg/day) for a three months treatment. Sample sizes varied for different studied points, since some children refused to take one or more measures.

RESULTS

Nutritional status and family income grouping: Malnutrition characterized as stunting (HAZ < -2), severe stunting (HAZ < -3) or underweight (WAZ < -2) was observed in 25.7%, 3.6% and 3.7% of the sample respectively, while 51.1% of the children had anemia (Table 1). Family income grouping showed that 67.4% of children belong to families with a monthly income between 133 and 266 USD, that corresponds to one and two minimum Brazilian wages and 14.9% belongs to families without cash-oriented activities, whose parents are farmers practicing subsistence agriculture (Table 1). Frequencies of stunting, severe stunting and anemia by family income strata are presented in Figure 1. Stunting and severe stunting were significantly more frequent in children belonging to families with no wage.

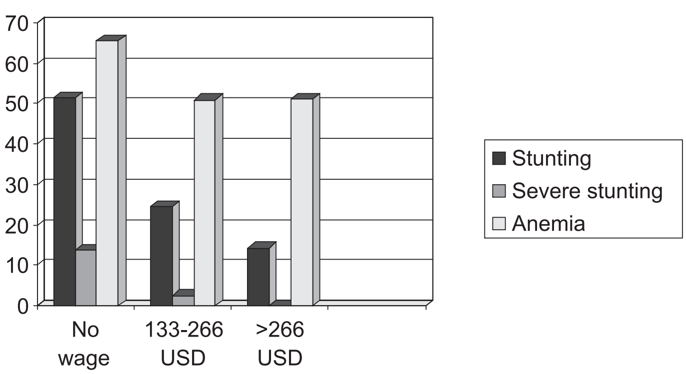

Fig. 1 - Comparison of frequencies[1] of stunting, severe stunting and anemia in children living in Santa Isabel do Rio Negro by family income group.
1- $p = 0.001$; $p = 0.001$ and $p = 0.31$ for stunting, severe stunting and anemia respectively (chi-square for trend).

Frequency and intensity of intestinal parasitic infections: Frequencies of intestinal parasitic infections are presented in Table 2, and 77.2% of subjects were infected with at least one enteric parasite. For *A. lumbricoides* infection, 29.5% of the infected children had an egg count below 5,000 eggs per gram (epg) of feces, 44.6% had a worm burden between 5,000 and 50,000 epg and 25.9% had a count above 50,000 epg. For trichuriasis, 91.4% of infected subjects presented a worm burden below 1,000 epg, while 8.6% of children had an egg count between 1,000 and 10,000 epg. All children infected with hookworms presented an egg count below 2,000 epg. Table 3 shows that infections by *A. lumbricoides*, hookworm, *S. stercoralis* and *E. histolytica/E. dispar* were significantly more common in children belonging to families without wages. Saprophytic protozoa were detected with the following frequencies: 32.6% for *Entamoeba coli*, 6.2% for *Iodamoeba butschlii*, 8.5% for *Endolimax nana* and 5.9% for *Chilomastix mesnili.*

Intestinal parasitism and its relationship with nutritional status: Bivariate analysis through ANOVA showed significantly lower means for WAZ, HAZ, WHZ and MUACZ in children infected with *G. lamblia,* for WAZ and HAZ in children harboring hookworms and HAZ for children with *A. lumbricoides* infection (Table 4).

Simple linear regression analysis did not show a relationship between intensity of *A. lumbricoides, T. trichiura* or hookworm infections expressed as epg and z-scores of anthropometric parameters.

Table 1
Sample characteristics

Characteristic		n
Gender, % female	50.8	307
Age groups, months, %		307
6 - 12	5.5	
13 - 24	17.6	
25 - 36	15.0	
37 - 48	19.9	
49 - 60	18.2	
61 - 72	16.0	
73 - 84	7.8	
Nutritional Status		
Stunting[1] (HAZ < -2), %	25.7	296
Severe stunting[1] (HAZ < -3), %	3.6	296
Underweight (WAZ < -2), %	3.7	297
Wasting (WHZ < -2), %	-	296
Hemoglobin, mg/dL[2]	10.84 ± 1.30	282
Anemia[3], %	51.1	282
Indian Language Group[4]		122
Baré	59.3	
Tukano	18	
Baniwa	11.3	
Pira-tapuya	7.3	
Tariana	2.7	
Desana	1.3	
Family income (monthly)[5,6]		242
No cash-oriented activities (subsistence agriculture), %	14.9	
133 - 266 USD, %	67.4	
> 266 USD, %	17.8	
Maternal education		286
Some elementary or no education	23.7	
Junior high school	27.8	
High school	42.6	
College	5.9	

1- 11 subjects refused to take anthropometric measurements and were excluded of analysis. 2- Value is mean ± SD. 3- Hemoglobin < 11 mg/dL for children aged six to 60 months and < 11.5 mg/dL for children older than 60 months (WHO 1999). 25 children refused the hemoglobin measurement and were excluded of analysis. 4- 185 children had parents who did not remember the ancestral Indian language group. 5- 65 subjects had missing values for socioeconomic data and were excluded of the multivariate analysis. 6- 133 USD = 1 Brazilian minimum wage.

Table 2

Frequency of intestinal parasites infection by age group in children in Santa Isabel do Rio Negro, Amazonas, Brazil, 2005[1]

Age group (months)	*Ascaris lumbricoides*	Hookworm	*Trichuris trichiura*	*Strongyloides stercoralis*	*Hymenolepis nana*	*Giardia lamblia*	*Entamoeba histolytica/ E. dispar*	*Cryptosporidium* spp.	*Blastocystis hominis*
6 - 12	1/17 (5.9)	-	-	1/10 (10)	-	1/17 (5.9)	-	-	-
13 - 24	19/54 (35.2)	3/51 (5.6)	7/54 (13)	3/41 (7.3)	-	11/54 (20.4)	3/54 (5.6)	1/54 (1.9)	6/54 (11.1)
25 - 36	17/46 (37)	-	11/46 (23.9)	-	2/46 (4.3)	16/46 (34.8)	3/46 (6.5)	1/46 (2.1)	12/46 (26.1)
37 - 48	24/61 (39.3)	2/61 (3.3)	14/61 (23)	4/48 (8.3)	3/61 (4.9)	19/61 (31.1)	9/61 (14.8)	-	29/61 (47.5)
49 - 60	25/56 (44.6)	3/56 (5.4)	16/56 (28.6)	4/43 (9.3)	2/56 (3.6)	17/56 (30.4)	9/56 (16.1)	-	31/56 (55.4)
61 - 72	25/49 (51)	7/49 (14.3)	18/49 (36.7)	-	1/49 (2)	17/49 (34.7)	9/49 (18.4)	1/49(2)	33/49 (67.3)
73 - 84	12/24 (50)	1/24 (4.2)	9/24 (37.5)	1/19 (5.3)	2/24 (8.3)	8/24 (33.3)	4/24 (16.7)	-	9/24 (37.5)
Total	123/307 (40.1)	16/307 (5.2)	75/307 (24.4)	13/238 (4.2)	10/307 (3.3)	89/307 (29)	37/307 (12.1)	3/307 (3)	120/307 (39.1)

1- Values are positive/performed examinations (%).

Table 3

Frequency of selected intestinal parasitic infections by family income group in children from Santa Isabel do Rio Negro, Amazonas, Brazil, 2005[1]

	Family income group			
Parasite	No wage	133-266 USD	> 266 USD	*p* (chi-square)
Ascaris lumbricoides	22/36 (61.1)	67/163 (41.1)	8/43 (18.6)	0.001
Trichuris trichiura	13/36 (36.1)	36/163 (22.1)	10/43 (23.3)	0.20
Hookworm	4/36 (11.1)	5/163 (3.1)	-	0.022
Strongyloides stercoralis	5/30 (16.7)	6/121 (5)	1/34 (2.9)	0.04
Giardia lamblia	10/36 (27.8)	53/163 (32.5)	11/43 (25.6)	0.62
Entamoeba histolytica/E. dispar	9/36 (25)	16/163 (9.8)	7/43 (16.3)	0.04

1- Values are positive/performed examinations (%).

Table 4

Comparison of anthropometric parameters z-scores means in children infected or uninfected with soil-transmitted helminths in Santa Isabel do Rio Negro, Amazonas, Brazil, 2005

	Ascaris lumbricoides		Hookworm		*Trichuris trichiura*		*Strongyloides stercoralis*		*Giardia lamblia*		*Entamoeba histolytica/ E. dispar*	
Variable	Inf[2]	Uninf[3]	Inf	Uninf	Inf	Uninf	Inf	Uninf	Inf	Uninf	Inf	Uninf
N	122	175	16	280	74	223	12	218	87	210	36	261
WAZ mean	-0.71	-0.62	-1.14[1]	-0.63[1]	-0.64	-0.66	-0.75	-0.60	-0.94[1]	-0.54[1]	-0.66	-0.65
N	119	177	15	280	71	225	12	216	85	211	36	260
HAZ mean	-1.42[1]	-1.16[1]	-1.88[1]	-1.23[1]	-1.34	-1.24	-1.65	-1.18	-1.51[1]	-1.17[1]	-1.38	-1.24
N	119	174	15	277	71	222	11	215	84	209	36	257
WHZ mean	0.15	0.23	0.18	0.15	0.24	0.15	0.49	0.18	0.00[1]	0.25[1]	0.29	0.16
N	81	131	7	204	46	166	11	152	58	154	21	191
MUACZ mean	-0.34	-0.26	-0.31	-0.29	-0.22	-0.31	-0.62	-0.26				

1- $p < 0.05$ on analysis of variance (ANOVA). 2- Inf = infected. 3- Uninf = uninfected.

Table 5

Multiple linear regression analysis of anthropometric parameters z-scores by *Giardia lamblia*, *Ascaris lumbricoides* and hookworm infections; family income strata, age and sex of children in Santa Isabel do Rio Negro, Amazonas, Brazil

	Dependent variables											
	WAZ			HAZ			WHZ			MUACZ		
	Coef[1]	SE[2]	*p*	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*
Independent Variables												
Giardia lamblia infection	-0.195	0.138	0.003	-0.118	0.154	0.072	-0.161	0.133	0.018	-0.197	0.143	0.011
Family income	0.212	0.117	0.002	0.255	0.130	0.000	0.049	0.112	0.483	0.188	0.123	0.022
Ascaris lumbricoides infection	-0.18	0.135	0.792	-0.049	0.151	0.469	0.012	0.130	0.864	0.030	0.143	0.712
Age	-0.049	0.003	0.55	0.034	0.004	0.602	-0.090	0.003	0.190	-0.193	0.004	0.013
Hookworm infection	-0.76	0.331	0.24	-0.070	0.386	0.287	-0.006	0.331	0.932	0.031	0.435	0.696
Gender	0.17	0.126	0.796	-0.001	0.140	0.987	0.012	0.121	0.858	-0.048	0.132	0.535

1- Coef = Coefficient. 2- SE = Standard error.

Multiple linear regression analysis showed interactions between *G. lamblia* infection and WAZ (beta = -0.195, SE = 0.138, $p = 0.003$), WHZ (beta = -0.161, SE = 0.133, $p = 0.018$) and MUACZ (beta = -0.197, SE = 0.143, $p = 0.011$), controlling for age, sex, family income, *A. lumbricoides,* and hookworm infections (Table 5). Also, the multivariate model showed that the only variable associated with hemoglobin levels was age.

DISCUSSION

This cross-sectional survey demonstrated the relationships between enteric parasitic diseases and some nutritional indicators in a sample of children living in an urban area in Brazilian Amazon. Data showed an interaction between *G. lamblia* infection and anthropometric parameters, suggesting that this protozoan affects the nutritional status of surveyed children. The study demonstrated that 29% of the children were infected with *G. lamblia.* These children had lower means for all studied anthropometric parameters on bivariate analysis. Even after adjustment for socioeconomic confounders, sex, age and other intestinal parasitosis, multiple linear regressions showed a significant interaction between *G. lamblia* infection and WAZ, WHZ and MUACZ. Multivariate analysis did not identified interactions between other enteric parasites and nutritional status despite hookworm and *A. lumbricoides* infections were associated with significantly lower means for some anthropometric parameters on the bivariate model. No interactions between intestinal parasitism and hemoglobin levels were observed. According to the worm burden's stratification proposed by MONTRESOR *et al.*[11], 25.9% of subjects presenting ascariasis had severe infections (up to 50,000 epg). All children harboring hookworms had light infections (below 2,000 epg). Also, 91.4% of children with trichuriasis had light infections (below 1,000 epg) and none presented high worm burdens (up to 10,000 epg). Such data probably contributed to the absence of relationship between those infections and nutritional status.

Other authors showed the relationship between *G. lamblia* infection and undernutrition in Africa[10], Asia[2] and Brazil[12] . ERTAN *et al*. (2002) demonstrated that *G. lamblia* infection is associated with lower serum levels of zinc and iron[6].

The role of *G. lamblia* on the etiology of chronic and persistent diarrhea is also recognized[1,14]. Persistent diarrhea and consequent malabsorption seriously affects nutritional status and growth. These conditions are still very common in Brazilian Amazon, affecting Indian children and those with Amerindian ancestry living in urban areas.

Unfavorable nutritional scenarios for Brazilian Indian children have been described in literature, with high frequencies of malnutrition, in surveys carried out in populations living in different stages of contact with the national society (see SANTOS 1993 for a review[19]). However, few studies aimed to understand changes occurring on an urbanization background. Rural emigration and urbanization in Amazon represents, in a small scale, demographic tendencies observed on more populated Brazilian regions. In the studied region, people originated from riverine communities, isolated in the forest, had migrated to the municipality's seat, living under very unfavorable conditions, in a context of poverty, low sanitation and high environmental contamination with excreta.

The poorest families, identified in this survey as those without regular wages, plant manioc for flour production, on subsistence agriculture. Liquid and soft foods made only with manioc flour and water, such as *chibé* and *maçoca*, are consistently given to infants and children to replace milk, also during weaning. Some other fruits and vegetables are produced by farmers and include *macaxeira*, banana, pineapple, *açai*, *cupuaçu* and potatoes. There is no excess production oriented for trading; planted foods are exclusively for familiar consumption. The survey suggests that familiar income strongly influences children's nutritional status and points to the existence of qualitative and quantitative nutritional gaps on available diets for different income groups. Multiple linear regression analysis showed an interaction between HAZ, WAZ and MUACZ and family income group. So, this variable was considered an important confounding factor in the assessment of the influence of intestinal parasitism on nutritional status, once children belonging to the poorest families have probably the worst sanitary conditions and presented a higher frequency of enteric parasitosis detection. *A. lumbricoides* and hookworm infections were significantly more frequent in children belonging to families with no wages. On the other hand, giardiasis did not show an income group distribution, affecting equally children belonging to the three socioeconomic strata. Data from this study suggest that social and environmental factors influence nutritional status in children living in the studied area.

Chronic malnutrition characterized as stunting is very frequent in Indian children living in Amazon. Studies suggest that this form of malnutrition has interrelated determinants that can be understood in a hierarchical structure. Proximal determinants are poor dietary intake and infectious diseases that are affected by family access to water, sanitation, and adequate health services. These conditions, in their turn, are influenced by structural factors at the societal level, within a political-economic context[22]. Our data showed that, although WAZ and WHZ were clearly influenced by *G. lamblia* infection, HAZ, the anthropometric parameter defining chronic malnutrition, presented a borderline interaction with giardiasis on the multivariate model and a significant association with this parasite on the bivariate analysis. Data suggests that giardiasis can acutely influence weight, probably through malabsorption, but chronic infection can potentially contribute to height deficits, being possibly one of the multiple determinants of the high prevalence of stunting observed in these communities.

This trial contributed to the comprehension of the factors that influence nutritional status of Indian children living in urban areas in Brazilian Amazon. It showed the influence of *G. lamblia* infection on anthropometric parameters and additionally demonstrated that family income strongly affects children's nutritional status.

RESUMO

Giardia lamblia e outros parasitas intestinais e sua relação com o status nutricional de crianças de uma área urbana na Amazônia Brasileira

O presente estudo objetivou avaliar a relação entre as parasitoses intestinais, o status nutricional e os níveis de hemoglobina em crianças vivendo em uma área urbana na Amazônia Brasileira. Foi realizado um estudo seccional, obtendo-se dados antropométricos, parasitológicos e socioeconômicos, além de dosagens de hemoglobina através do fotômetro *Hemocue*®, de crianças com idade entre seis e 84 meses. Os dados da antropometria foram expressos como escores de desvio-padrão (escores z) para os parâmetros peso-idade (PI), altura-idade (AI), peso-altura (PA) e perímetro braquial-idade (PBI). Os exames parasitológicos foram realizados através dos métodos de Ritchie (n = 307), Kato-Katz (n = 278), Baermann-Moraes (n = 238) e Safranina-Azul-de-Metileno (n = 307). A regressão linear múltipla demonstrou interações independentes entre *Giardia lamblia* e PI (beta = -0.195, p = 0.003), PA (beta = -0.161, p = 0.018) e PBI (beta = -0.197, p = 0.011), após controle para idade, sexo, renda familiar e infecções por *Ascaris lumbricoides* e ancilostomídeos. O modelo multivariado demonstrou ainda que a única variável associada aos níveis de hemoglobina foi a idade. O estudo concluiu que a giardíase está associada, nos sujeitos pesquisados, a menores médias para os parâmetros antropométricos estudados e que um controle efetivo das parasitoses intestinais poderia contribuir para o pleno desenvolvimento das crianças na área estudada.

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