# Interactions between malnutrition, soil-transmitted helminthiasis and poverty among children living in periurban communities in Maranhao State, Northeastern Brazil

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## ABSTRACT

Poverty, malnutrition and neglected tropical diseases such as soil-transmitted helminthiases (STHs) interact in a multi-causal feedback network. This study aimed to assess the relationships between STHs, income and nutritional status of children in impoverished communities in the city of Caxias, Maranhao State, Northeastern Brazil. A cross-sectional survey (n=259 children) was carried out with the collection of fecal samples and assessment of sociodemographic, anthropometric, dietary and sanitation data. Hookworm infection and ascariasis presented prevalence rates of 14.3% and 9.3%, respectively. The logistic regression analysis showed that hookworm infection was more frequent in males (odds ratio [OR]=3.43; 95% confidence interval [CI]=1.45-8.08), children aged 11-15 years old (OR=3.72; 95% CI=1.19-11.62), children living in poor families (OR=2.44; 95% CI=1.04-5.68) and those living in rented houses (OR=5.74; 95%CI=1.91-17.25). Concerning ascariasis, living in the Caldeiroes community (OR=0.01; 95%CI=0-0.17) and belonging to the 11-15 years age group (OR=0.21; 95%CI=0.04-1.02) were protection factors. Poor children have a significantly lower frequency of consumption of meat, milk, vegetables, tubers and fruits than not poor children. The frequent consumption of meat, milk and tubers was associated with significant higher values in the parameter height-for-age, whereas the consumption of meat and milk positively influenced the weight-for-age. The frequencies of stunting, underweight and wasting were 8.1%, 4.9% and 2.9%, respectively. The multivariate model demonstrated that stunting was significantly associated with economic poverty (OR=2.82; 95%CI=1.03-7.70) and low weight was associated with male sex (OR=6.43; 95% CI=1.35-30.68). In conclusion, the study describes the interactions between the dimensions of development represented by income, STHs and nutritional status revealing the importance of raising income levels to improve the living conditions of families in impoverished communities in Northeastern Brazil.

**KEYWORDS:** Malnutrition. Soil-transmitted helminthiases. Poverty. Northeastern Brazil. Childhood infections.

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**Received:** 24 June 2020

**Accepted:** 1 September 2020

## INTRODUCTION

The United Nations defined seventeen Sustainable Development Goals (SDGs) to be achieved by 2030. Among the SDGs are the reduction by at least half the proportion of people living in poverty, ending all forms of malnutrition and ending epidemics

of waterborne and neglected tropical diseases[1]. These three goals interact in a multi-causal feedback network.

Soil-transmitted helminthiasis (STHs) are conditions with clear socio-environmental determinants, whose prevalence is high in scenarios of economic poverty and inadequate sanitation[2,3]. The prevalence rates of STHs in Brazil have shown a downward trend, following the social development achieved by the country in the last decades[4-6]. STHs are caused by hookworms (*Necator americanus* and *Ancylostoma duodenale*), *Ascaris lumbricoides*, *Trichuris trichiura* and *Strongyloides stercoralis*. Depending on parasitic loads, hookworms are associated with varying degrees of iron deficiency anemia[7], *A. lumbricoides* can cause intestinal obstruction, *T. trichiura* is associated with dysentery and rectal prolapse and *S. stercoralis* can cause severe intestinal infection, sometimes with systemic dissemination. While hookworm and *S. stercoralis* transmission is more frequently percutaneous, *A. lumbricoides* and *T. trichiura* are orally transmitted. This may be associated with different dynamics and risk factors, with hookworms and *S. stercoralis* being more associated with the inadequate destination of feces in the peridomestic environment and *A. lumbricoides* and *T. trichiura* more dependent on inadequate supply of clean water and consumption of clean food[8]. However, it should be considered that hookworms can also be transmitted orally and their transmission is influenced by the contamination of water and food.

The regular use of anthelmintics such as albendazole and mebendazole has been the main measure to control STHs, aiming to control parasitic loads and reduce transmission. In Brazil, this policy was made official with the National Campaign for Leprosy, Schistosomiasis, STHs and Trachoma[9]. A comprehensive national survey of STHs found prevalence rates of hookworm, ascariasis and tricuriasis of 4.5%, 8.3% and 5.9%, respectively, in the Northeast region. In Maranhao State, these rates were 15.8%, 17.5% and 5.8%, respectively, showing that STHs are still endemic in the State[10].

The proportion of the population living in poverty in Brazil was reduced to 49% in 2000 and 34% in 2010. In 2020, the proportion was 56% in the Northeast, 53% in the North, 26% in the Midwest, 24% in the Southeast and 19% in the South[11]. The poverty rate fell from 26.5% in 2017 to 25.3% in 2018, still higher than in 2012 when the pre-recession rate was 22.8%. In Brazil, the proportion of chronic malnutrition characterized by low height in boys and girls was reduced, respectively, from 29.3% and 26.7% in 1975 to 7.2% and 6.3% in 2009[12]. The prevalence of weight deficit in boys and girls was reduced, respectively, from 5.7% and 5.4% to 4.3% and 3.9% in the same period[12].

Some studies have attempted to assess the impact of STHs on the nutritional status of children, showing conflicting results, since some point to the relative parasite-host balance and others suggest damage to physical and cognitive development[13-16]. The lack of control of confounding factors, such as income and differences in access to food, may explain these differences. The multiplicity of possibilities for interaction between income, diseases and nutritional status has been assessed through qualitative approaches[17-19]. This study aimed to assess the relationships between STHs, income and nutritional status of children in impoverished communities in the city of Caxias, Maranhao State, Northeastern Brazil.

## MATERIALS AND METHODS

### Description of the studied area

The study was carried out in the municipality of Caxias, Maranhao State, located in Northeastern Brazil (04°51'32"S and 43°21'21"W), with an area of 5,196.771 km² and 155,129 inhabitants. The municipality of Caxias is located in the Eastern region of Maranhao State, at an altitude of 66 meters. The climate is semi-humid tropical, with a minimum temperature of 22.4 °C, a maximum of 32.6 °C and an annual average of 26.8 °C. The climate of the municipality region, according to the Köppen classification, is tropical (AW') with a rainy period from January to June, with monthly averages greater than 216.6 mm and a dry period from July to December. The municipality of Caxias has a transition vegetation between the Mata de Cocais area, the pre-Amazon and the Cerrado. The municipality has a human development index (HDI) of 0.624, only 26.5% of houses have adequate sanitation and 2.8% of public roads are paved[20]. About 76% of the population lives in the urban area, and the proportion of people living in poverty in the municipality is 58%. Livestock, plant extraction, permanent and temporary crops, government transfers and public employment are major sources of funds for the population. The study was carried out in the impoverished periurban communities Caldeiroes and Bacuri, located on the outskirts of the municipality (Figure 1).

### Study design, sample size and recruitment

A cross-sectional survey was carried out in the studied communities, which were visited by the researchers between December 2019 and January 2020. The researchers carried out home visits with the community health agents. The visits aimed to recruit participants, distribute plastic containers without preservatives for the collection of fecal samples and assess sociodemographic, anthropometric, dietary and
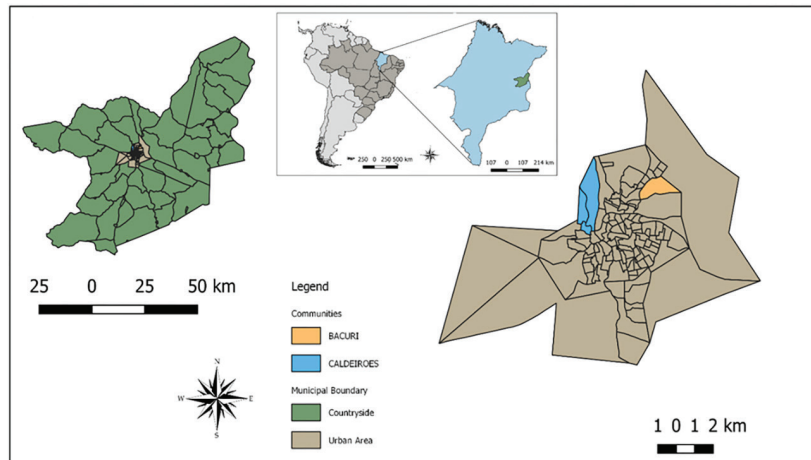
**Figure 1** - Location map of the communities of Bacuri and Caldeiroes, in the municipality of Caxias, Maranhao State, Northeastern Brazil.

sanitation data through personal interviews; 139 families/houses (90 in Caldeiroes and 49 in Bacuri) were visited and fecal samples from 259 children were collected. The sample size was calculated taking into account a population of approximately 1000 children in the two communities, an expected frequency of 10% of intestinal parasites, an acceptable margin of error of 3% and a confidence level of 95%. The questionnaires were applied to each child, individually. Data were collected in two stages, the first in Caldeiroes and the second in Bacuri, with sociodemographic information and anthropometric measurements collected simultaneously in each community. All children in the defined age group, who lived in the communities of Bacuri and Caldeiroes were considered eligible for the study. Children with chronic clinical conditions that could influence the nutritional status were excluded.

### Geospatial analysis of soil-transmitted helminthiases

The households were georeferenced with a GPS at the time of the visits. The program QGIS was used (version 2.18.28, QGIS Development Team, QGIS Geographic Information System, Open Source Geospatial Foundation, Boston, MA, USA), raster module, heat map; 200 m and 100 m radius were used to analyze the spatial distribution of hookworms and *A. lumbricoides*, respectively.

### Anthropometry

Weight and height were obtained in children aged 2 to 15 years[21]. Weight was measured using a digital floor scale. The standing height was measured with a tape perfectly aligned to a straight surface. The upper mid arm circumference was measured with a tape, as recommended[22]. With these values, the z-scores of the anthropometric

indicators height for age (HAZ), weight for age (WAZ) and weight for height (WHZ) were calculated, using the NutStat module of the Epi Info 2000 Version 3.5.2 program (Centers for Disease Control and Prevention, Atlanta, USA). Short stature for age, low weight for age and short stature for weight were defined by values equal to or less than -2 for HAZ, WAZ and WHZ, respectively. Severe stunting was defined by a value below -3 for HAZ[23]. Although there is some variation in weight throughout the day, for logistical reasons the children's weights were obtained at different times, in the morning and in the afternoon.

### Parasitological techniques

For all children whose caregivers agreed to participate in the research, a container without preservatives for collecting on the fecal sample was made available. The samples were sent to the Fiocruz Piaui laboratory. Samples were initially analyzed using the Lutz's technique followed by a flotation technique, the Willis-Mollay method. For the detection of *S. stercoralis*, the Rugai's method was used[24-26]. For all hookworm-positive samples, the Harada-Mori technique[27] was also performed in order to detect and differentiate larvae of *S. stercoralis* and the hookworms *N. americanus* and *A. duodenale*. The results of the exams were given to those responsible for the children and those who were infected, were treated with anti-helminthics (for STHs) and/or secnidazole (for pathogenic protozoa).

### Qualitative assessment of food consumption

Those responsible for the children answered questions about the consumption patterns of different food groups. Responses on the consumption of meat, milk, eggs, cereals, tubers, legumes and processed foods were categorized as

occasional (when consumption was sporadic or less than 3 times a week) or regular (when consumption was equal to or greater than three times a week).

### Assessment of family income

Those responsible for the children were asked about all sources of family income, adding the values and dividing them by the number of family members, to calculate the monthly family income per capita. Poverty was defined when this value was below R$132, which corresponds to 26 USD (considering the exchange rate of 1 USD = R$ 5). This is the value that defines the greatest vulnerability of families and is used by the Ministry of Social Development to include them in government programs to supplement income.

### Statistical analysis

In order to assess factors associated with STHs, crude and adjusted (logistic regression model) odds ratios were calculated in the different subgroups defined by sociodemographic characteristics. Regarding the qualitative data on food consumption, the frequencies of regular consumption of distinct foods were compared between poor and not poor children using the Fisher's exact test. The means of anthropometric parameters HAZ, WAZ and WHZ were compared between children with regular or sporadic consumption of different types of food, using the Student's t test. Variables associated with the presence of stunting and low weight were assessed using bi- and multivariate models by logistic regression. The statistical significance was set at $p < 0.05$ for bi- and multivariate analyses.

### Ethics

This study was approved by the Research Ethics Committee of the University Center for Science and Technology of Maranhao (UniFacema), license N° 16368319.0.0000.5248. Informed consents from all individuals were obtained. For children and adolescents <18 years old, the consent form was completed by the legal guardians. Children and adolescents also provided an assent form.

## RESULTS

### Prevalence, distribution and factors associated with soil-transmitted helminthiasis

In the studied communities, hookworm and *A. lumbricoides* infections were detected, with prevalence rates of 14.3% (37/259) and 9.3% (24/259), respectively.

The detection frequencies of *Enterobius vermicularis*, *Hymenolepis nana* and *T. trichiura* eggs were 5% (n = 13), 3.5% (n = 9) and zero, respectively. The prevalence of intestinal strongyloidiasis was 2.3% (5/222) as 37 fecal samples had insufficient volume to perform the Rugai's technique. The multivariate model by logistic regression demonstrated that the positivity rate for hookworms was significantly higher in males, children aged 11-15 years old, children living in poor families and in rented houses. Concerning ascariasis, living in the Caldeiroes community and the 11-15 years age group were protection factors (Table 1). The maps in Figure 2 show the hot spots of hookworm and *A. lumbricoides* infections.

### Income, access to different types of foods and nutritional status of studied children

Among the 259 children included in the study, 126 (48.6%) belonged to families with an income below R$ 132 (26 USD), while 133 (51.4%) belonged to families with an income above this value. The proportion of children that belonged to families receiving a supplementary income from the government (Bolsa Familia Program) was 202/259 (78%). The proportion of children benefited by the Bolsa Familia Program was 103/126 (82%) in children classified as poor and 98/133 (74%) in not poor children. As shown in Table 2, poor children have a significantly lower frequency of consumption of meat, milk, vegetables, tubers and fruits than not poor children. However, the frequency of consumption of eggs, cereals, processed foods, sausages and pasta was not influenced by the income. The mean values of HAZ, WAZ and WHZ were -0.44±1.10, -0.45±1.04 and -0.27±1.18, respectively. Frequent consumption of meat, milk and tubers was associated with significant higher values in the nutritional parameter HAZ, whereas meat and milk positively influenced WAZ, as shown in Table 3.

### Interactions between malnutrition, income and soil-transmitted helminthiasis

The frequencies of stunting, underweight and wasting were 8.1% (21/259), 4.9% (n = 11/259) and 2.9% (5/173), respectively. As presented in Table 4, the multivariate model by logistic regression demonstrated that stunting was significantly associated with economic poverty and low weight with male sex.

## DISCUSSION

The results of this study demonstrated the interplay between STHs, income and nutritional status in children

**Table 1** - Distribution and factors associated with *Ascaris lumbricoides* and hookworm infections in 259 children in the municipality of Caxias, Maranhao State, Brazil, 2020.

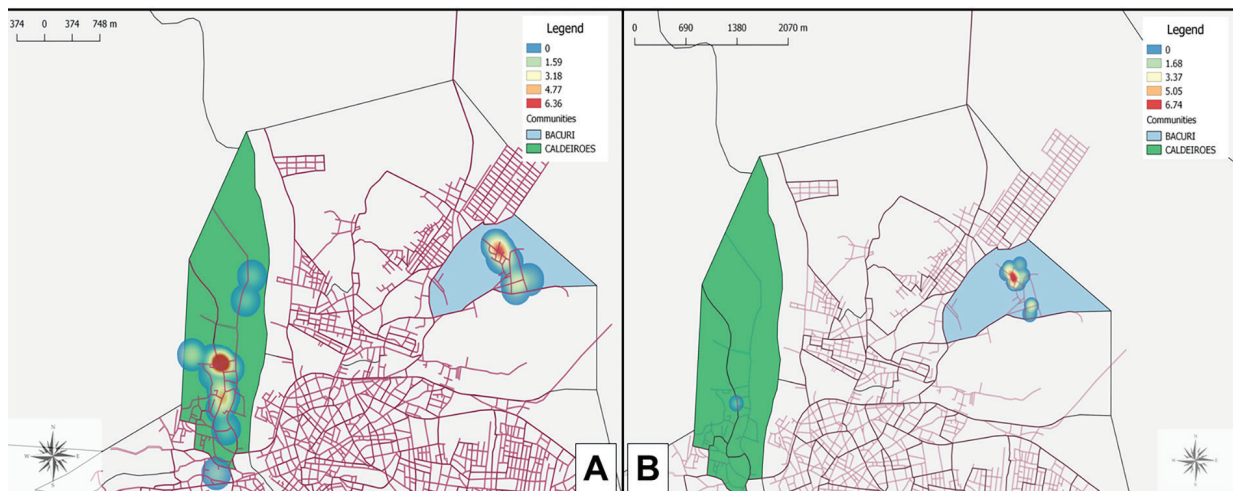| | *Ascaris lumbricoides* | | | | | Hookworms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Positive/ tested (% positive) | Crude OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value | Positive/ tested (% positive) | Crude OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value |
| Community | | | | | | | | | | |
| Caldeiroes | 1/158 (0.6) | 0.02 (0-0.16) | | 0.01 (0.001-0.17) | 0.001 | 24/158 (15.2) | 1.21 (0.58-2.50) | 0.371 | 0.48 (0.18-1.28) | 0.145 |
| Bacuri | 23/101 (22.8) | 1 | < 0.001 | 1 | | 13/101 (12.9) | 1 | | 1 | |
| Age group (years) | | | | | | | | | | |
| 0-5 | 9/78 (11.5) | 1 | | 1 | | 6/78 (7.7) | 1 | | 1 | |
| 6-10 | 13/107 (12.1) | 1.06 (0.42-2.62) | 0.544 | 1.42 (0.48-4.23) | 0.518 | 13/107 (12.1) | 1.65 (0.60-4.57) | 0.231 | 1.72 (0.58-5.05) | 0.323 |
| 11-15 | 2/74 (2.7) | 0.21 (0.04-1.02) | 0.034 | 0.28 (0.05-1.63) | 0.160 | 18/74 (24.3) | 3.85 (1.43-10.35) | 0.006 | 3.72 (1.19-11.62) | 0.023 |
| Sex | | | | | | | | | | |
| Male | 12/122 (9.8) | 1.13 (0.49-2.63) | 0.831 | 1.56 (0.56-4.33) | 0.391 | 26/122 (21.3) | 3.10 (1.46-6.58) | 0.001 | 3.43 (1.45-8.08) | 0.004 |
| Female | 12/137 (8.8) | 1 | | 1 | | 11/137 (8) | 1 | | 1 | |
| Poverty | | | | | | | | | | |
| Yes | 10/126 (7.9) | 0.73 (0.31-1.71) | 0.525 | 0.62 (0.21-1.86) | 0.400 | 27/126 (21.4) | 3.35 (1.54-7.26) | 0.001 | 2.44 (1.04-5.68) | 0.038 |
| No | 14/133 (10.5) | 1 | | 1 | | 10/133 (7.5) | 1 | | 1 | |
| Open evacuation | | | | | | | | | | |
| Yes | 12/90 (13.3) | 2.01 (0.86-4.68) | 0.116 | 21.18 (0.83-538.68) | 0.064 | 17/90 (18.9) | 1.73 (0.85-3.50) | 0.088 | 0.92 (0.13-6.41) | 0.935 |
| No | 12/169 (7.1) | 1 | | 1 | | 20/169 (11.8) | 1 | | 1 | |
| House status | | | | | | | | | | |
| Own house | 22/229 (9.6) | 1 | | 1 | | 27/229 (11.8) | 1 | | 1 | |
| Rented house | 2/30 (6.7) | 0.67 (0.14-3.01) | 0.454 | 5.55 (0.50-61.58) | 0.162 | 10/30 (33.3) | 3.74 (1.58-8.82) | 0.003 | 5.74 (1.91-17.25) | 0.002 |
| Presence of latrine | | | | | | | | | | |
| Yes | 13/174 (7.5) | 1 | | 1 | | 21/174 (12.1) | 0.67 (0.32-1.40) | 0.195 | 0.78 (0.11-5.55) | 0.807 |
| No | 11/83 (13.3) | 1.89 (0.80-4.42) | 0.105 | 18.35 (0.68-488.62) | 0.082 | 14/83 (16.9) | 1 | | 1 | |
| Albendazol in the last 6 months | | | | | | | | | | |
| Yes | 4/48 (8.3) | 0.84 (0.27-2.58) | 1.000 | 0.67 (0.17-2.59) | 0.572 | 5/48 (10.4) | 0.65 (0.23-1.77) | 0.278 | 1.12 (0.36-3.53) | 0.835 |
| No | 20/205 (9.8) | 1 | | 1 | | 31/205 (15.1) | 1 | | 1 | |



**Figure 2** - Kernell maps showing the geospatial distribution and hot zones of hookworm infections (A) and *Ascaris lumbricoides* (B) in the communities of Bacuri and Caldeiroes, city of Caxias, Maranhao State.

**Table 2** - Patterns of consumption of different foods according to the family income group in 259 children in the municipality of Caxias, Maranhao State, Brazil, 2020.

| | Per capita monthly family income | | |
| --- | --- | --- | --- |
| | Poverty (n=126) Number of children with regular consumption (%) | Non-poverty (n=133) Number of children with regular consumption (%) | p-value |
| Food | | | |
| Meat | 59 (46.8) | 110 (82.7) | < 0.001 |
| Milk | 66 (52.4) | 96 (72.2) | < 0.001 |
| Eggs | 69 (54.8) | 76 (57.1) | 0.397 |
| Cereals | 122 (96.8) | 131 (98.5) | 0.316 |
| Tubers | 17 (13.5) | 40 (30.1) | < 0.001 |
| Legumes | 35 (27.8) | 61 (45.9) | 0.002 |
| Processed foods | 24 (19) | 26 (19.5) | 0.522 |
| Sausages | 47 (37.3) | 47 (35.5) | 0.420 |
| Fruits | 50 (40) | 81 (60) | < 0.001 |
| Pasta | 86 (68.3) | 96 (72.2) | 0.289 |

**Table 3** - Comparison of means of anthropometric parameters in 259 children with different consumption patterns of different foods in the municipality of Caxias, Maranhao State, Brazil, 2020.

| | HAZ (mean±SD) | | | WAZ (mean±SD) | | | WHZ (mean±SD) | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Occasional consumption | Frequent consumption | p-value | Occasional consumption | Frequent consumption | p-value | Occasional consumption | Frequent consumption | p-value |
| **Food** | | | | | | | | | |
| Meat | -0.86±1.07 | -0.22±1.04 | <0.001 | -0.72±1.01 | -0.30±1.03 | 0.002 | -0.36±1.12 | -0.22±1.21 | 0.450 |
| Milk | -0.66±1.13 | -0.31±1.07 | 0.011 | -0.62±-0.34 | -0.34±1.03 | 0.037 | -0.39±1.13 | -0.19±1.21 | 0.288 |
| Eggs | -0.38±1.08 | -0.71±1.13 | 0.455 | -0.39±1.06 | -0.49±1.03 | 0.435 | -0.26±1.29 | -0.27±1.09 | 0.954 |
| Cereals | -0.13±1.54 | -0.45±1.09 | 0.494 | -0.79±1.02 | -0.44±1.05 | 0.428 | -0.81±1.17 | -0.25±1.18 | 0.257 |
| Tubers | -0.52±1.05 | -0.15±1.23 | 0.025 | -0.48±1.01 | -0.34±1.15 | 0.377 | -0.23±1.21 | -0.41±1.08 | 0.420 |
| Legumes | -0.43±1.07 | -0.45±1.16 | 0.901 | -0.50±0.97 | -0.37±1.16 | 0.340 | -0.44±0.98 | 0.02±1.43 | 0.011 |
| Processed foods | -0.43±1.14 | -0.50±0.95 | 0.667 | -0.45±1.02 | -0.43±1.14 | 0.866 | -0.28±1.17 | -0.24±1.22 | 0.857 |
| Sausages | -0.40±1.04 | -0.52±1.21 | 0.396 | -0.45±0.95 | -0.44±1.20 | 0.908 | -0.33±1.08 | -0.16±1.08 | 0.373 |
| Fruits | -0.53±1.10 | -0.36±1.11 | 0.214 | -0.41±1.06 | -0.49±1.03 | 0.556 | -0.24±1.06 | -0.29±1.28 | 0.786 |
| Pasta | -0.53±1.02 | -0.40±1.14 | 0.408 | -0.55±0.99 | -0.41±1.06 | 0.312 | -0.29±1.13 | -0.26±1.20 | 0.876 |

living in poor communities in Maranhao State, Brazil. Data showed that poverty is associated with a higher frequency of hookworm infection, a lower consumption of foods with higher protein content, such as meat and milk and higher frequency of chronic malnutrition characterized by stunting.

Regarding hookworm infections, the prevalence was significantly higher in children with lower income, living in rented houses. Hookworm was also more frequent in male adolescents, suggesting a greater exposure to contaminated soil in this group. These associations were not observed for ascariasis, which, on the contrary, was more frequent among pre-school and school children. Infection with *A. lumbricoides* was more frequent in the Bacuri community, showing a more focal spatial pattern. For this study, we did not employ sensitive parasitological techniques for the microscopic identification of enteric protozoa. Failure to assess the correlation of *Giardia duodenalis* infection with poverty and nutritional status is therefore a limitation of this study, as this parasite is able to reduce the absorption of nutrients in the small intestine[28].

**Table 4** - Factors associated with malnutrition in 259 children in the municipality of Caxias, Maranhao State, Brazil, 2020.

| | Stunting | | | | | Low weight | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stunted/ evaluated (% positive) | Crude OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value | Low weight/ evaluated (% positive) | Crude OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value |
| Age group (years) | | | | | | | | | | |
| 0-5 | 7/78 (9) | 1 | | 1 | | 1/78 (1.3) | 1 | | 1 | |
| 6-10 | 6/107 (5.6) | 0.60 (0.19-1.86) | 0.397 | 0.56 (0.18-1.80) | 0.337 | 6/107 (5.6) | 4.57 (0.53-38.78) | 0.240 | 5.12 (0.58-44.57) | 0.138 |
| 11-15 | 8/74 (10.8) | 1.22 (0.42-3.57) | 0.789 | 0.95 (0.30-2.97) | 0.935 | 4/74 (5.4) | 4.40 (0.48-40.31) | 0.200 | 5.86 (0.61-55.85) | 0.124 |
| Sex | | | | | | | | | | |
| Male | 13/122 (10.7) | 1 | | 1 | | 9/122 (7.4) | 5.37 (1.13-25.39) | 0.018 | 1 | |
| Female | 8/137 (5.8) | 0.52 (0.20-1.30) | 0.176 | 0.53 (0.20-1.38) | 0.195 | 2/137 (1.5) | 1 | | 0.14 (0.03-0.69) | 0.016 |
| Hookworm infection | | | | | | | | | | |
| Yes | 4/37 (10.8) | 1.46 (0.46-4.61) | 0.354 | 0.96 (0.27-3.40) | 0.956 | 0/37 (0) | undefined | | undefined | - |
| No | 17/222 (7.7) | 1 | | 1 | | 11/211 (5) | | | | |
| *Ascaris lumbricoides* infection | | | | | | | | | | |
| Yes | 1/24 (4.2) | 0.46 (0.05-3.64) | 0.397 | 0.52 (0.06-4.29) | 0.549 | 1/24 (4.2) | 0.97 (0.11-7.98) | 0.664 | 1.31 (0.14-12.06) | 0.810 |
| No | 20/235 (8.5) | 1 | | 1 | | 10/225 (4.3) | 1 | | 1 | |
| Poverty | | | | | | | | | | |
| Yes | 15/126 (11.9) | 2.86 (1.07-7.62) | 0.024 | 2.74 (1.00-7.53) | 0.049 | 7/126 (5.6) | 1.89 (0.54-6.49) | 0.239 | 2.27 (0.62-8.32) | 0.213 |
| No | 6/127 (4.5) | 1 | | 1 | | 4/133 (3) | 1 | | 1 | |

According to the last STHs National Survey, Maranhao State reached the highest prevalence of hookworm in Brazil, which in the age group between 7 and 17 years reached a rate of 18.2% in boys and 13.3% in girls[10]. This rate is more than twice as high as that of Para State, the second State with the highest prevalence of hookworm infections[10]. It is important to note that some studied families still practice open defecation, which is a determining factor for the perpetuation of hookworm transmission[29,30]. Regarding *A. lumbricoides* infection, Maranhão presents the second highest prevalence rate (19% in boys and 16% in girls), slightly below Amazonas State[10]. *S. stercoralis* infections were observed in the communities, which is a relevant fact, since the STHs national survey does not use, for operational reasons, Rugai or Baerman-Moraes techniques, so that the prevalence rates of strongyloidiasis are unknown in several areas. Moreover, it is noteworthy that *S. stercoralis* is not targeted by MDA campaigns, it is not sensitive to albendazole, being ivermectin and thiabendazole the most effective drugs for treatment.

Almost half of the studied population had an income below 26 USD per month. The assessment of differences in the consumption patterns of distinct foods in children with different income levels revealed that poor children consumed foods such as meat and milk less frequently. In addition, the lowest consumption frequencies of these foods were associated with lower values in the anthropometric parameters HAZ and WAZ. It has been demonstrated that chronic malnutrition has distal determinants defined by political and economic backgrounds, and proximal determinants, such as low protein diet and infectious diseases[31]. As has been shown, low values in the height-age indicator are strongly determined by the characteristics of the diet, which in turn are influenced by the income[31]. The multicentric Malnutrition and Enteric Disease Study (MAL-ED) demonstrated the influence of the percentage of energy obtained from protein in the children's diet on the anthropometric parameter HAZ and consequently on the prevalence of stunting. In the present study, it was clear that income determines the frequency of eating protein foods such as meat and milk. The micro regional differences in the nutritional status of children in different income groups have been demonstrated in Gambia and Bangladesh[32,33]. In Ghana and Nepal, increased dietary diversity has been able to increase the nutritional status of children in rural communities[34,35].

## CONCLUSION

The study points to the importance of raising income levels to improve the living conditions of families in impoverished communities in Northeastern Brazil.

## CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

## FINANCIAL SUPPORT

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