
EPIDEMIOLOGY AND PREDICTORS OF OCCURRENCE OF *Schistosoma mansoni* INFECTION IN A LOW-ENDEMICITY AREA IN NORTHEAST BRAZIL

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ABSTRACT

In Latin America 96% of the cases of schistosomiasis occur in Brazil in low-socioeconomic status populations. The epidemiological characteristics and occurrence predictors of *Schistosoma mansoni* infection were determined in the Bananeiras community, located in Capistrano, a town in Ceará state, Brazil. Sanitary, environmental, socioeconomic, and behavioral data were collected using a semi-structured questionnaire. An investigation to assess *S. mansoni* infection was conducted using the Kato-Katz and Point-of-Care Circulating Cathodic Antigen (POC-CCA) methods. From the 258 subjects were analyzed, 54.3% (n=140) were women, median age 30 years. Thirty-three (12.8%) individuals were positive by either egg- and/or CCA-positivity. The highest positivity rate was found in the 30-39 year old group. There was no piped water supply, sewage network or municipal refuse collection service. Most individuals were illiterate or had not finished elementary school (66.3%). About 29.1% of the families had a monthly income below one Brazilian minimum wage and 91.1% reported contact with natural water sources. We found an association between infection and age group of 20-40 years, illiteracy, household with 7 inhabitants or more, household with up to 3 rooms and an outhouse. Contrarily, being 40 years old or older and household with up to 6 inhabitants were not risk factors. Schistosomiasis remains a public health problem in this municipality, evidencing a strong association with low socioeconomic conditions and high vulnerability. These findings reinforce the importance of identifying the factors associated with the infection for more effective guidance in actions in control programs targeting schistosomiasis prevention and control.

KEY WORDS: Schistosomiasis; *Schistosoma mansoni*; epidemiology; predictors; low endemicity; urine antigen.

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INTRODUCTION

Schistosomiasis is still a serious public health problem affecting more than 240 million people in 78 countries. Some 800 million people live in endemic areas in countries located mainly in Africa, Asia and Latin America (Weerakoon et al., 2015). Brazil is accountable for 96% of the cases of schistosomiasis in Latin America, which occur in low socioeconomic status populations, mainly in the northeastern region (Brazil, 2014). An estimated 1.5 million people are infected in Brazil according to the national prevalence survey carried out between 2011 and 2014. (Katz et al., 2018). All regions of the country have recorded transmission of the disease, covering 18 states and the Federal District. The main endemic areas are located in the states of Alagoas, Bahia, Maranhão, Paraíba, Pernambuco, Rio Grande do Norte and Sergipe (Northeast Region); Espírito Santo and Minas Gerais (Southeast Region); while the focal areas are in the States of Pará (North Region), Ceará and Piauí (Northeast Region), Rio de Janeiro and São Paulo (Southeast Region), Paraná, Santa Catarina and Rio Grande do Sul (South Region), and Goiás (Midwest Region) (Brazil, 2019).

In a nation-wide study on neglected tropical diseases over a 12-year period, Chagas disease was the most common cause of death (76.7%), followed by schistosomiasis (8.2%) and leishmaniasis (4.5%) (Martins-Melo et al., 2016). Schistosomiasis persists as a neglected cause of death in Brazil, in spite of reduced mortality. Regional differences are significant (Martins-Melo et al., 2014). Especially the highly schistosomiasis-endemic areas along the coast of the Brazilian Northeast Region, which presented high-risk death clusters according to a spatiotemporal analysis (Martins-Melo et al., 2015). There was an average of 508 deaths from the disease per annum in Brazil (2006-2015) (Brazil, 2019).

Measures in control program implemented over the last decades have been mainly based on parasitological examinations of stool samples in endemic areas, followed by disease-oriented drug therapy and population-based treatment programs, using antischistosomal drugs such as praziquantel (Bergquist, 2001). These measures led to a reduction in schistosomiasis morbidity and mortality, but the disease was not eliminated. Schistosomiasis control remains a challenge. Migration combined with the broad geographic distribution of intermediate hosts and poor sanitary conditions favor the sustainability and establishment of new disease foci in Brazil (Brazil, 2014).

Understanding the dynamics of the sociodemographic and behavioral determinants of schistosomiasis transmission is crucial in the study of endemic areas. Housing and sanitation, hygiene, income and educational level are very important determinants for infectious diseases (Rollemberg et al., 2015).

Between 2008 and 2012 Capistrano was one of the five municipalities in Ceará state with the highest prevalence of this disease still with foci of intestinal

schistosomiasis with low parasite loads (Brasil, 2013). The epidemiology may vary strongly from one locality to another depending on local determinants (Gryseels, 2012). In this context, this study aimed to determine the positivity rate, epidemiological characteristics and occurrence predictors of *S. mansoni* infection in a low-endemicity area in Northeastern Brazil.

MATERIAL AND METHODS

Study Area

The study was carried out in the Bananeiras community (Figure 1), a rural locality of the Capistrano municipality (Geocode 2302909), in Ceará State, Brazil (geographical coordinates 4° 28' 20''S latitude, 38° 54' 14''W longitude). The estimated population in Capistrano in 2017 was 17,668 individuals, with a population density of 76.67 inhabitants per km². The municipal Human Development Index in 2010 was 0.731, with an average monthly income among formal workers in 2015 of 1.9 Brazilian minimum wages. Adequate sanitary sewage in 2010 reached 56.6% of the inhabitants (PNUD, 2013).

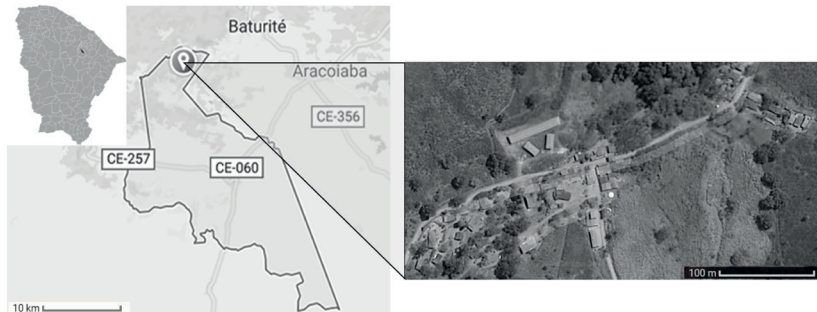


Figure. The location of the community of Bananeiras in the Capistrano municipality in Ceará state. Adapted: Google Maps.

The Bananeiras community was chosen due to the 1.6% positivity rate of schistosomiasis reported in 2010 (Kato-Katz technique) and the community having had no specific treatment plan for schistosomiasis in the previous two years (Ceará, 2013). There is a Federal Family Health Program unit in Bananeiras, which was still being built at the time of the study, with a permanent staff consisting of a part-time physician, a dentist and a nurse. The Bananeiras community was also included in the “water for all” project sponsored by the Ceará State Government.

The region, which is endemic for *S. mansoni*, presents a semi-arid climate so the Aracoiaba river that crosses the village remains dry most of the year (flood season between December and March). The river crosses the Bananeiras community at 3 points, approximately 200 m, 500 m and 800 m from the community's Federal Family Health Program unit. Although there was no street lighting, household electricity was accessible to the entire community. In addition, the community has only one Elementary school.

Study design and population

This was a descriptive cross-sectional epidemiological study. Inclusion criteria: (a) age ≥ 2 years at recruitment; (b) informed consent; (c) willingness to answer a questionnaire and to provide stool and urine samples; (d) no recent treatment for schistosomiasis (at least over the past two years). The door-to-door census carried out in this study in the Bananeiras community in March 2013, covered 80 homes with 297 inhabitants aged 2 or older.

Data collection

Questionnaire

In April 2013, sanitary, environmental, socioeconomic status and behavioral data were gathered by means of a semi-structured questionnaire. Variables: age, gender, housing conditions and sanitation, i.e. water supply, general sewage network and type of sewage system (open-air sewage or septic tank), waste destination, number of family members per household, number and type of bathrooms, number of rooms; schooling (illiterate, Elementary school, high school, or undergraduate); labor activities (current employment and/or other work activities); family income [converted into US dollars (USD) in this manuscript] and contact with natural water sources. The latter was assessed through questions on whether the subjects had contact with local water bodies (yes/no) and what type of contact (multiple yes/no responses: carrying water from the river, washing clothes/dishes, swimming, crossing, irrigating vegetables, farm work, fishing, bathing and carrying sand from the river).

Laboratory procedures

The diagnostic survey was performed between April and July 2013 using two methods: i) parasitological detection by Kato-Katz technique; and ii) *Schistosoma* detection in urine using Circulating Cathodic Antigen (CCA, adult worm gut-associated antigen). Three Kato-Katz thick smear slides per

stool sample were prepared using the Helm-Test® (Biomanguinhos-Fiocruz, Rio de Janeiro, RJ, Brazil) (Katz et al., 1972).

Fresh morning urine samples were tested using a commercially available Point-of-Care –CCA (POC-CCA) cassette test (Batch no. 33,827, Rapid Medical Diagnostics, Pretoria, South Africa) performed at room temperature on the day of sample collection according to the manufacturer’s instructions. All individuals received a single dose of praziquantel, 50 mg/kg for adults and 60 mg/kg for children (≤ 15 years of age) free of charge, regardless of infection status (Farmanguinhos, Ministry of Health, Brazil) (Brazil, 2014).

Data management and analysis

A database was created using the Epi Info® software (version 3.5.4, Centers for Disease Control and Prevention), summarized and expressed descriptively. The positivity rate of infection was estimated as the percentage of eggs and/or CCA-positives, considering “trace” readings as positive; intensity of infection was expressed as arithmetic mean eggs per gram of feces (EPG); positive individuals were categorized into classes of egg counts (WHO, 2011). Study adherence was calculated as the percentage of people provided with collection containers who returned stool and urine samples. The association between the independent variables and the outcome (*S. mansoni* infection) was analyzed using the Prevalence Ratio (PR) in the Statistical Calculator app, available at the Center for Quantitative Methods in the Medical School of Ribeirão Preto/Universidade de São Paulo (<http://stoa.usp.br/edsonzm/files/2423>, accessed on August 10, 2017). A 5% level of significance was adopted for all inferential procedures.

Ethical Considerations

The Universidade Federal do Ceará Ethical Committee approved the study design (application n° 302.204) conducted according to Resolution 466/12 of the Brazilian Health Council. Written informed consent was obtained from all participants in the study.

RESULTS

Of the 285 enrolled individuals, 258 (90.5%) participated in the study; 54.3% (n=140) were women, the median age was 30 years (age range, 2-87 years). The remaining twenty-seven were absent on the sample collection days or had insufficient stool samples to undergo triplicate Kato-Katz thick smears.

In the Kato-Katz, 4 (1.6%) subjects tested positive. All of them were classified as having a very low-intensity infection, with arithmetic means of fecal egg counts of 8 EPG. Thus, Bananeiras was classified as a low-endemic area for schistosomiasis (Cavalcanti et al., 2013). 10 POC-CCA positive cases (3.9%) were detected; 20 cases were scored as trace (7.7%). Thirty-three participants had positive results by either egg-counts and/or CCA with a positivity rate of 12.8 cases per 100 inhabitants in the year 2013 (Table 1).

There was no association between infection and gender (19 females vs. 14 males; $p=0.683$). The highest positivity rate was verified in adults, regardless of gender, particularly in the 30-39 age group. The ages of the egg-positive individuals ranged from 33 to 47 years. Three egg-positives were in the 30-39 age group and one in the 40-49 age group, whereas the ages of the CCA-positive individuals ranged from 2 to 87 years. Six (20%) CCA-positives were in the 2-9 age group, 7 (23.3%) in the 10-19, 6 (20%) in the 20-29, 7 (23.3%) in the 30-39, 1 (3.3%) in the 40-49 and 3 (10%) in the 60 and older age group. Table 1 shows the population and the positivity rate per 100 inhabitants according to age group and gender.

The village had no piped water supply, with artesian wells being the main source of water in the community (73.2%). We emphasize that 11% of the individuals had the river as their only source of water. The locality did not have a sewage network; 30.3% had a septic tank, while the others reported that the waste was dumped directly into the river (39.0%), or thrown out in the open (29.9%). There was also no municipal refuse collection service and the main destinations were incineration (55.5%) or open air (39.0%).

Most individuals were illiterate or had not finished Elementary school (66.3%). The most frequently mentioned occupations were farming (37.2%) or unemployment (24.4%). About one-third (29.1%) of the families had monthly incomes below the Brazilian minimum wage (US\$ 339 at the time) and most of the population (73.6%) received some type of government assistance: *Bolsa Família* (55.7%), *Garantia-Safrá* (16.2%), or both (27.6%). Most of the houses were owned by the individuals (88.4%), were built of bricks (94.6%), had 3 or 4 inhabitants (46.9%), 5 (27.5%) or 6 (28.3%) rooms and only one bathroom (86.0%); most of which were indoor bathrooms (72.5%), but a little more than half of these bathrooms had no running water (51.9%).

Almost all of them (91.1%) reported contact with natural water sources, mainly crossing the river (86.4%), recreational purposes (48.4%) and household activities- washing clothes and dishes (36.4%).

When stratifying the epidemiological characteristics of this population an association between infection by *S. mansoni* and the following were detected: household with up to 3 rooms, outhouse, household with 7 inhabitants or more, illiteracy and age group of 20 to 40 years. However, being 40 years old or older and household with up to 6 inhabitants were not risk factors. The PR values and 95% confidence intervals (95% CI) are shown in Table 2.

Table 2. Association of *S. mansoni* infection with sociodemographic factors. Bananeiras, Capistrano, Ceará State, Brazil, 2013.

Sociodemographic factors	PR	95% CI
age group of 20 to 40 years	2.06	1.1-3.86
being 40 years old or older	0.35	0.14-0.88
being illiterate	2.13	1.03- 4.57
domicile with up to 6 inhabitants	0.42	0.18-0.95
domicile with 7 inhabitants or more	2.4	1.05-5.47
domicile with up to 3 rooms	3.66	1.72-7.79
outhouse	2.63	1.34-5.15

PR, prevalence ratio; CI, confidence interval.

DISCUSSION

The study area presented poverty and precarious basic sanitation. Almost all of the individuals reported contact with natural water. Crowded small domiciles without an indoor bathroom, illiteracy, and adult age were risk factors for the infection in this community, where schistosomiasis remains a relevant public health problem.

Characteristics such as living in households with up to 3 rooms, living with 7 or more cohabitants and the presence of an outhouse resulted in a greater risk factor associated with schistosomiasis in this community. These conditions indicate the precariousness of households and reflect the low socioeconomic status of their residents. These risk factors are reinforced by low income, with a monthly average below the minimum wage and a high percentage (70%) of this population living with some type of government assistance, in addition to the high illiteracy rate. In this context, Nascimento et al. (2019) conducted a study on the cost of schistosomiasis in Brazil in 2015 and the key points for the correct decision in control programs. They concluded that this disease

has a greater impact in endemic areas with poor living and health conditions, so sustainable actions for the elimination of its transmission require not only improvement in basic sanitation and drinking water, but mandatory adequate housing, education and access to health care. Gryseels (2012) also reinforces the importance of improving the living conditions of these communities through political and socioeconomic development, combating poverty which is the cause and consequence of schistosomiasis.

The lack of bathrooms inside the homes can reinforce the habit noted in residents from these poor rural communities of bathing in the river and defecating near the river. This is a cultural aspect still present in different Brazilian regions, as described in areas of Pernambuco, another state in the Brazilian Northeast, by Saucha et al. (2015). These authors point out the need for health education action, respecting the socio-cultural values of the population, so that new generations abandon these unhealthy habits in the long run.

Historically, the Schistosomiasis Control Program has determined the 7 to 14 age group as a sentinel population for its actions in Brazil (PECE, 1976). However, we found the highest positivity rate (30-39 years) and the highest risk in an older, economically active age group. In fact, high prevalence can persist among adult subpopulations that have continuous contact with water during their daily activities (Colley et al., 2014). Our data are similar to a study carried out by Souza-Gomes et al. (2014), in an area with inadequate infrastructure in another state of Northeastern Brazil, where individuals aged 20 to 40 had greater contact with natural waters, as they needed to cross through these flooded environments more frequently in order to carry out their social and labor activities.

Furthermore, in this study a change was noted in the social behavior of young people and adolescents based on recent technological advances. Many children and teenagers choose to stay at home using social media, playing electronic games and even watching TV, while the adult women go to the river to do household chores. Surprisingly, this may even have an influence on the contact profile with natural water sources in rural communities. It is noteworthy that 12% of the *S. mansoni* positive cases were children under the age of six, which reinforces the fact that infants and young children are at risk of schistosomiasis as described elsewhere (Colley et al., 2014; Coulibaly et al., 2013).

There was no piped water supply, sewage network or municipal refuse collection service. We found that 11% of the individuals had the river as their only source of water. Indeed, Rolemberg et al. (2011) emphasize that sanitation status influences the degree of environmental contamination of the municipalities by *S. mansoni* eggs, so where there is a better sewage network, the prevalence of schistosomiasis is lower.

Although farming is well documented in the literature as a risk factor (Rollemberg et al., 2015), no increased risk of schistosomiasis was detected among individuals with this occupation, probably since they were not ‘true’ farmers. In fact, during the application of the questionnaires several housewives and even vendors were noted marking the farming option in the occupation evaluation. They explained that they had to do this to be eligible for the General Social Security System.

Contact with natural sources of water as an indicative of risk behavior was reported by almost the entire population of Bananeiras, especially regarding river crossing. Throughout the numerous visits to the Bananeiras community, we noted that access to this community during the rainy season is only possible along an unpaved partially flooded dirt road. It is in these small streams formed during this season that the women of the village gather to wash clothes and dishes, while the younger children play and bathe in the same water, which is also where the men fish. Contact with open water sources in most rural settings is inevitable; therefore, preventive measures are necessary to stop the contamination of open water bodies, as well as health education, to promote a behavioral modification in the population (Rollinson et al., 2013). Importantly, we found little schooling among these individuals, as described elsewhere (Rollemberg et al., 2015). However, even if educational programs can improve knowledge about the disease and health-care, the current behavior can hardly be expected to change without other water source options (Sow et al., 2003).

The Kato-Katz technique extensively used in *S. mansoni* diagnosis has several disadvantages (e.g., high day-to-day variation in stool egg concentrations) (Kongs et al., 2001). It has very limited sensitivity in areas of low endemicity settings, where the number of excreted eggs is often low and multiple Kato-Katz thick smears are needed (Siqueira et al., 2015; Pinheiro et al., 2012; da Frota et al., 2011). Thus, other field-applicable methods are required to attempt to reveal the ‘true’ prevalence of infection (Sousa et al., 2019; Sousa-Figueiredo et al., 2013). The POC-CCA test is valuable for the detection of *S. mansoni* in endemic areas (Colley et al., 2013; van Dam et al., 2015), and in an accompanying previous article (Bezerra et al., 2018) showed a seven-fold increase in prevalence versus Kato-Katz technique in the same community. However, the POC-CCA test is a qualitative method based on an individual interpretation (visually read), and the true significance of the ‘trace’ readings (light lines) commonly observed in low-endemic areas has been investigated (Coelho et al., 2016; Colley et al., 2017). In fact, there is a reduced performance of POC-CCA test in individuals with low parasite loads, and the test subjectivity and the need for reading standardization have been discussed (Sousa et al., 2019; Siqueira et al., 2016; Colley et al., 2013; Casacuberta et al., 2016). In addition, Coelho et al. (2016) showed that hookworm infection influences POC-CCA test results.

Eliminating schistosomiasis with drugs alone, without additional measures regarding water supply, education and basic sanitation is unlikely to succeed (Gryseels et al., 2006). In the 1950s, Japan was able to eliminate schistosomiasis by combining this approach with basic sanitation, water supply and environmental interventions (Minai et al., 2003).

The analysis of the epidemiological profile of a community contributes to the identification of key information factors such as those associated with the infection, aiding health authorities in directing the development of socio-environmental actions, mainly combating poverty, which combined with mass screening and treatment, can effectively eliminate *S. mansoni* transmission foci in these most affected areas.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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