Journal of Medical and Biological Science Research
Vol. 1 (6), pp. 62-70, August, 2015
ISSN: 2449-1810
Research Paper
http://pearlresearchjournals.org/journals/jmbsr/index.html

Risk Factors to Schistosomiasis in Communities from Minas Gerais State, Brazil: The Importance of Baseline Studies for Evaluations in the Endemic Area

Erica Barbosa Magueta[1,2], Alessandra Miranda[2], Rosiane Araujo S Carvalho[2], Alda Maria Soares Silveira[1], Elizabeth Castro Moreno[3,4] and Lucia Alves de Oliveira Fraga[1*]

Accepted 12 August, 2015

[1]Universidade Federal de Juiz de Fora - Campus Governador Valadares, Rua Israel Pinheiro, 2000, Universitário, Governador Valadares, MG, Brazil.
[2]Núcleo de Pesquisa em Imunologia, Faculdade de Ciências da Saúde, Universidade Vale do Rio Doce / UNIVALE, Rua Israel Pinheiro, 2000, Universitário, Governador Valadares, MG, Brazil.
[3]Departamento de Parasitologia do Instituto de Ciências Biológicas da Universidade Federal de Minas Gerais, Av. Antônio Carlos, 6627, Pampulha, Belo Horizonte, MG, Brazil.
[4]Fundação Centro de Hematologia e Hemoterapia de Minas Gerais, Hemominas, Rua Grão Pará, 882, Santa Efigênia, Belo Horizonte, Minas Gerais, Brazil.

ABSTRACT

This cross-sectional study was designed to determine the extent of schistosomiasis and to identify the risk factors associated in an endemic area well-known for its high prevalence called Córrego do Bernardo (CB) and Córrego do Melquíades (MQ), located in the East part of Minas Gerais State, Brazil. Structured and pre-coded questionnaires were used to explore individual and household characteristics. Although geographically close, CB and MQ have shown distinct patterns of infection. The prevalence in CB was estimated in 12.5% (95% CI=8.4-17.8) and 31.9% (95% CI= 25.3-38.5) in MQ (p<0.005). In CB, males are more likely to be infected (OR=4.6, 95%CI=1.6-13.3) while public water supply (OR=0.3, 95%CI=0.1-0.7) and family history of infection with *Schistosoma mansoni* (OR=0.3, 95%CI=0.1-0.9) are characteristics associated with a lower chance of infection. In MQ the characteristics associated with the disease were co-infection with other helminthes (OR=4.3, 95%CI=1.6-11.5) and the use of water from cisterns (OR=2.1, 95%CI=1.1-4.2). The disease remains a problem in these communities. Investment in basic sanitation and education remains an important strategy for the control of the disease and should be directed towards the specific factors. The characterization of these communities could be useful for temporal analyses and reevaluations of resistance and susceptibility to infection.

Key words: Cross-sectional study, Endemic area, Epidemiology, Prevalence, risk factors, *Schistosoma mansoni*.

*Corresponding author. E-mail: luciaalvesfraga@yahoo.com.br. Tel: (33) 32795983 Celular: (33) 88629849.

INTRODUCTION

Schistosomiasis is considered worldwide as a serious public health problem. It has been reported that 600 million people are at risk of infection with about 200 million people infected (WHO, 2005). In Brazil, the disease is identified in 19 Federal States, among them stands Minas Gerais presenting pattern of uneven distribution with high prevalence found in the Northeastern and Eastern regions of the State (Brasil, 2010; Brasil, 2012; Fonseca et al., 2014). The Schistosomiasis Control Program (PCE) proposes as a strategy the collective treatment of infected individuals, combined with other preventive actions, such as routine parasitological examination in the population of endemic areas, hospital surveillance in severe forms of the disease, training of health professionals to actions for diagnosis, treatment and health education (Farias et al., 2007; Brasil, 2012).

However, the control of this infection is still considered as a serious problem. Achieving this goal is hampered by the diversity of factors involved in transmission of the parasite, such as the pattern of contact with contaminated water during work or leisure activities, presence of water snails of the genus *Biomphalaria,* age, genetic and immunologic conditions of the host (Farias et al., 2007; Pereira et al., 2010; Fonseca et al., 2014; Rowel et al., 2015). During the last three decades, schistosomiasis has been studied in the endemic area of northeast of Minas Gerais State including the rural areas of the municipality of Governador Valadares (Gazzinelli et al., 1992; Bethony et al., 2001). The historical recurrence of infection in the treated population and, on the other hand, the existence of cases that are resistant to infection despite frequent exposure, are both intriguing and many studies have already been conducted in order to investigate immunological factors related to this disease in this area (Webster et al., 1997; Fraga et al., 2010). Despite this, the current distribution of the disease in this community and the evaluation of associated factors now a day are unknown. This cross-sectional study allowed an assessment of *Schistosoma mansoni* prevalence, the evaluation of intensity of infection and the comparison of the risk factors associated in two close communities that have been affected by schistosomiasis for many years.

MATERIALS AND METHODS

Study Area and Population

The study was conducted in 2009 in a rural area including two districts CB and MQ, both located in the municipality of Governador Valadares, State of Minas Gerais. The districts are only 15 km along the road from each other. According to the local health authorities, 760 inhabitants live in the district of CB and 900 in MQ. A sample size of these populations was calculated using the software OpenEpi, v2.3 based on the following parameters: (1) prevalence of schistosomiasis rate of 20% for each district; (2) confidence level of 0.05; (3) precision of estimated prevalence of 5% and (4) total number of inhabitants of the study areas. The value for schistosomiasis prevalence was based on previous studies carried out by our group and on results of parasitological surveys of the health services of the municipality (Gazzinelli et al., 1992; Bethony et al., 2001). A sample of 186 inhabitants in CB and 194 in MQ was estimated for this study. The sample size was increased by 10% in order to avoid losses during the study. A simple random sampling procedure of households was chosen for the selection of the participants in both areas. All residents of each selected household were invited to participate.

Data Collection

Structured and pre-coded questionnaires were applied to investigate: (1) demographic data (age, gender and educational level), (2) socioeconomic data (family income, numbers of residents in home, occupation) (3) characterization of the houses, (availability of electricity, sanitary conditions, and water source), (4) knowledge about the disease transmission, (5) habits and water contact pattern and (6) history of prior infection. A total of 117 families (59 in CB and 58 in MQ), representing 449 individuals (212 in CB and 237 in MQ) were interviewed. The data were entered into a database specifically structured for this study, using the software Epi Data 2.1a.

Parasitological Survey

Stool containers marked with the name and a specific identification number for each participant were distributed on three consecutive days for sample collection. Two slides of each stool sample were prepared resulting in a total number of six slides per participant, which were examined according to the Kato-Katz technique (Katz et al., 1972). The first stool sample was also assessed by the sedimentation method described by Hoffman et al. (1934).

Statistical Analysis and Ethical Aspects

The statistical analysis was performed using frequency distribution of all qualitative variables and measures of central tendency for quantitative variables. Comparisons between the districts and infected and uninfected individuals were initially performed using univariate analysis. Variables with more than 2 categories were analyzed as dummies. Chi-square or Fisher tests were used for qualitative variables, "t" test for quantitative variables, and crude *odds ratio* for quantification of association between single putative risk factors and *S. mansoni* infection. All variables showing a significance level of 0.20 were included in multivariable logistic models. Variables that presented low frequency ($n \leq 3$) were excluded of multivariate analysis.

The models were constructed using the backward

Table 1. Demographic characteristics of the population from the districts of Córrego do Bernardo and Córrego do Melquíades, Governador Valadares, and Minas Gerais.

Variable	Córrego do Bernardo n=212 (%)	Córrego do Melquíades n=237 (%)	p value
Gender[a]			
Male	93 (44.7)	121 (51.1)	
Female	115 (55.3)	116 (48.9)	0.167[c]
Age			
Mean ± SD	33.1 ± 23.0	33.8 ± 22.1	0.764[d]
Min-Max	1-88	1-86	
Median (1Q/3Q)	M=28 (13/52)	M=30 (13/52)	
Skin color[a]			
Black	5 (2.5)	17 (7.2)	
Brown	175(85.8)	177 (74.7)	
White	24 (11.8)	43 (18.1)	0.004[c]
Education[b]			
College or more	5 (2.5)	4 (1.8)	
High school	24 (12.1)	26 (11.7)	
Elementary school	148 (74.4)	157 (70.4)	
Never studied	22 (11.0)	36 (16.1)	0.476[e]
Employment status[a]			
Student	65 (33.7)	61 (27.5)	
Rural worker	48 (24.9)	61 (27.5)	
Housewife	34 (17.6)	34 (15.3)	
Retired	28 (14.5)	37 (16.7)	
Technician	13 (6.7)	19 (8.5)	
Unemployed	5 (2.0)	10 (4.5)	0.592[c]

[a] Excluded individuals without information; [b] excluding under 6 years old; [c] χ^2
[d] t test and [e] Fisher test.

process and statistical significance was determined by likelihood ratio tests. The evaluation of risk factors was performed by calculating the adjusted *odds ratio* and 95% of confidence intervals using Stata/IC 11 program (Stata Corporation, 2009). The survey was conducted considering the resolution 196/96 of the National Health Council of Ministry of Health/Brazil and the project received approval by the Ethics Committee in Research at Universidade Vale do Rio Doce (019/08-11).

RESULTS

The demographic characteristics of the population in both districts are presented in Table 1. The proportion of the participants by gender and age was similarly distributed in the two districts ($p > 0.05$). CB and MQ have a young population with a median age of 28 and 30 years old, respectively. The percentage of individuals younger than 20 years was 41.2% (n = 84) in CB and 36.4% (n = 87) in MQ showing no statistically significant difference ($p>0.05$). More than 80% of the participants have only basic educational level or no formal education in both districts. Also, no significant difference was observed concerning occupation of the sampled population in both areas. Around 30% of the participants in both districts reported to be students, and about 25 and 15% are rural workers and housewives, respectively. The only demographic characteristic that differed between the two districts was color of skin: the proportion of black or white skin is greater in MQ, meanwhile the proportions of mixed is greater in CB ($p<0.05$).

The average time that the participants have been living in these districts is similar (M=20.5, 1/3 IQR=11/41 in CB and M=22.0, 1/3 IQR=11/44). There were also no differences among the districts concerning numbers of persons per house (3.8 and 4.3) or familiar income (up to 2 minimum wages = 622 US$).

The characteristics of the houses in both districts were also very similar ($p>0.05$). The majority were built of solid bricks (67.2% in CB and 55.2% in MQ) or mud bricks (27.6% in CB and 36.2% in MQ). The type of the roofs was the unique external feature which differs between the districts. In MQ the coverage of the houses is of better quality than in CB, using clay roof tiles (84.5% in MQ and 46.6% in CB). On the other hand, the proportion of houses with asbestos tile is higher in CB than in MQ (36.2% in CB and 8.2 % in MQ) ($p<0.05$). A small fraction of houses has no bathroom (6.1% in CB and 6.9% in MQ).

All houses in both districts had access to electric energy, and only about 30% were supplied with treated water (37.9% in CB and 29.3% in MQ). Most of the houses used untreated water of cisterns or wells (32.8% in CB and 44.8% in MQ) ($p> 0.05$). In less than 10% of the houses, individuals reported to use stream water for their household activities (8.6% in CB and 6.9% in MQ) ($p> 0.05$). The use of springs for water supply was more frequent in CB (41.4%) than in MQ (27.6%) ($p<0.05$). Agriculture in both districts is based in subsistence planting. The main crops grown in CB were corn and manioc (42.9% for both). In MQ, the cultivation of corn (46.7%) and beans (28.4%) was the most common. Manioc, banana and sugarcane planting are more frequent in CB than in MQ ($p < 0.005$).

In MQ, the percentage of people that reported growing rice currently is not significantly higher (14.9%) than in CB (4.1%).($p>0.05$). Personal habits and behavior were also investigated and all the variables that showed significant difference at the level of 0.20 between the two districts are represented in Table 2. The proportion of workers who reported planting rice in the past in MQ (70.6 %) was significantly higher than in CB (41.1%) ($p<0.05$). Concerning the destination of the feces, a high percentage of people reported using bathrooms (about 90% in both districts), however 14.7% of respondents in CB and 10.6% in MQ declared not using them ($p>0.05$), and as an alternative, making the outdoors their toilet. Although the main destination for feces is the cesspool (about 90%) for those who declared using bathrooms, there are still some houses with inappropriate waste disposal. In MQ, the frequency of waste directly connected to stream is higher (9.2%) than in CB (1.6%) ($p<0.05$).

The most common reason for contact with stream water was leisure (49.4% in MQ vs. 27.0% in CB ($p=0.000$). The use of stream water for domestic activities was more frequent in MQ (29.2%) than in CB (9.8%); the same applied for work related activities (MQ=20.8% vs. CB=10.3%) ($p\leq 0.003$). About 90% of the residents of both areas reported had already done stool tests and the prevalence rate of *S. mansoni* infection in the past years was significantly higher in MQ (62.0%, 95%CI=55.3-68.3) than in CB (31.2%, 95%CI==24.7-38.4) ($p<0.05$) as estimated by the answers of the respondents (Table 3). The participants of both districts related on average 1.5 to 2.0 previous infections, the majority (90.9% in CB and 96.0% in MQ) remember being treated. On the other hand, 4 individuals in each district declared they are not treated despite having positive exam results. In the present survey, stool samples were collected from 192 individuals in CB and 188 in MQ. Considering the sample size previously estimated the percentage of losses was 3.1% in MQ. No losses were registered in CB.

The prevalence of 31.9% (95%CI=25.3-38.8) for schistosomiasis in MQ was significantly higher than in CB (12.5%, 95%CI=8.4-17.8) ($p<0.05$). The ratio of infected/uninfected people was 1:2 in MQ and 1:7 in CB. Other parasitic diseases also identified in the survey were hookworm, *Entamoeba histolytica/dispar, Ascaris lumbricoides, Giardia lamblia* and *Enterobius vermicularis*. Rates of infection were higher in MQ for *E. histolytica/dispar* (24.5% vs. 10.9% in CB) and *A. lumbricoides* (3.7% vs. 0.5% in CB). Among the 60 individuals infected with *S. mansoni* in MQ, 25 (41.7%, 95%CI=30.1-54.3) showed co-infection with other intestinal parasites (helminthes and/or protozoa) compared to 5 (20.8%, 95%CI=9.2-40.5) out of 24 individuals in CB ($p=0.04$). The infected individuals presented a low worm burden of *S. mansoni* in both districts. However, the participants from MQ showed a significantly higher parasite load (32 eggs per gram of feces) than CB (15 eggs per gram of feces) ($p<0.05$) (Table 4). Despite the similarities between the two districts, as the two populations showed some differences in their behavior, history and current infections, besides being slightly different in relation to the type of habitation, univariate and multivariate analysis were performed for each one separately, comparing infected and non-infected individuals to identify the predictors of infection in each district.

The variables that attained a significance level of 0.20 in univariate analysis in CB and their respective crude odds ratio were: gender (male and female, OR=3.9, 95%CI=1.5-9.9), use of outdoors as toilet (OR=2.2, 95%CI=0.7-6.8), access to public treated water supply (OR=0.3, 95%CI=0.3-0.8), family history of schistosomiasis (OR=0.3, 95%CI= 0.1-0.8) and knowledge about the disease (OR=0.3, 95%CI=0.1-0.9). In MQ, the variables less than 0.20 significance level and their crude odds ratio were: age up to 20 years (OR=2.0, 95%CI=1.2-4.2), use of cisterns as source of water (OR=2.4, 95%CI=1.2-4.7) domestic activities involving stream water (OR= 1.7, 95%CI=0.9-3.3), work-related activities involving stream water (OR=1.9, 95%CI= 0.9-4.0), co-infections with geo-helminthes (OR=3.6, 95%CI=1.5-8.7), knowledge about the disease (OR=0.26, 95%CI 0.1-0.9) and family history of schistosomiasis (OR=3.3, 95%CI=.07-15.4). These variables were included in the final multivariate analysis for each district and the results of logistic models and the adjusted odds ratios are presented in Table 5.

In CB, males presented higher risk of infection than females (AdOR=4.6; CI95%=1.6-13.3), while in MQ there

Table 2. Comparison between districts of Córrego do Bernardo and Córrego do Melquíades, Governador Valadares and Minas Gerais.

Variable	Córrego do Bernardo n=212 (%)	Córrego do Melquíades n=237 (%)	p value[b]
Have ever worked with the planting of rice [a]			
Yes	60 (41.1)	120 **(70.6)**	
No	86 (58.9)	50 (29.4)	0.000
Do toilet outdoors			
Yes	30 (14.7)	25 (10.6)	
No	174 (85.3)	210 (89.4)	0.199
Destination of feces [a]			
Stream	3 (1.6)	20 (9.2)	0.001
Cesspool	180 (98.4)	196 (89.9)	
Type of the roofs[a]			
Clay roof tiles	27 (46.6)	49 (84.5)	0.000
Asbestos	21 (36.2)	5 (8.2)	
Mixed (without predomant material)	7 (12.1)	4 (3.5)	
Concrete ceiling	3 (5.2)	-	
water used in the home[(a)(c)]			
Treated public water	22 (37.9)	17 (29.3)	0.551
Cisterns or wells	19 (32.8)	26 (44.8)	0.199
Springs	24 (41.4)	16 (27.6)	0.038
Streams	5 (8.6)	4 (6.9)	0.804[(2)]
Reason for contact with stream water [a]			
Leisure	55 (27.0)	116 (49.4)	0.000
Domestic activities	20 (9.8)	69 (29.2)	0.000
Work-related activities	21(10.3)	49 (20.8)	0.003

Only the variables that attained a significance level of 0.20 are showed. [a] Excluded individuals without information; [b] χ^2 [and c] Some families declared the use of more than one source of water.

Table 3. Estimates of prevalence for past and current infections with *S. mansoni* in the districts of Córrego do Bernardo and Córrego do Melquíades, Governador Valadares and Minas Gerais.

Infection	Córrego do Bernardo	Córrego do Melquíades	p value
Past infection[a]	55 (31.2%) (95%CI=24.7-38.4)	132 (62.0%) (95%CI=55.3-68.3)	0.000
Current infection	24 (12.5%) (95%CI=8.4-17.8)	60 (31.9%) (95%CI= 25.3-38.8)	0.000

[a] Reported past infection (individuals without information were excluded). Numbers in parenthesis show the proportion of infection: number of infected/those who have done parasitological exams, according the reported or exams realized.

was no association between infection and gender. Co-infection with other geo helminthes (Hookworms, *A. lumbricoides, E. vermicularis* and *T. trichiuria*) was associated with schistosomiasis in MQ (AdOR= 4.3;

Table 4. *S. mansoni* egg count per gram of feces among individuals from districts of Córrego do Bernardo and Córrego do Melquíades, Governador Valadares and Minas Gerais.

***S.mansoni* egg count**	**Córrego do Bernardo (n=21)**	**Córrego do Melquíades (n=57)**	**p value**
Geometric Mean	15	32	0.000[a]
Min-max	4-76	4-664	
Median (1Q/3Q)	16 (8-36)	28 (8-92)	

[a] t test using normalized values log (x+1) were x=eggs per gram of feces.

Table 5. Multivariate analysis: Risk factors for infection with *S. mansoni* in the districts of Córrego do Bernardo and Córrego do Melquíades, Governador Valadares and Minas Gerais.

Variables	**Infected Individuals n (%)**	**Uninfected Individual's n (%)**	**Crude OR (95%CI)**	**Adjusted OR (95%CI)**
		Córrego do Bernardo		
Gender[a]				
Female	7 (29.2)	101 (61.6)	1	1
Male	17 (70.8)	63 (38.4)	3.9 (1.4 - 11.7)	4.6 (1.6-13.3)
Public water supply[a]				
No	7 (33.3)	101 (64.3)	1	1
Yes	14 (66.7)	56 (35.7)	0.3 (0.1 - 0.8)	0.3 (0.1-0.7)
Family history of infection with *S. mansoni*[a]				
No	9 (42.9)	29 (18.0)	1	1
Yes	12 (57.1)	132 (82.0)	0.3 (0.1 - 0.9)	0.3 (0.1-0.9)
		Córrego do Melquíades		
Co-infection with geo-helminthes[a]				
No	46 (76.5)	118 (92.2)	1	1
Yes	14 (23.3)	10 (7.8)	3.6 (1.5 - 8.9)	4.3 (1.6-11.5)
Water from cistern[a]				
No	16 (27.1)	60 (47.2)	1	
Yes	43 (72.9)	67 (52.8)	2.4 (1.2-4.8)	2.1 (1.1-4.2)

[a] Individuals without information were excluded.

CI95%= 1.6-11.5), as well as the use of cisterns as a source of water (AdOR=2.1, CI95%=1.1-4.0). Some characteristics are confirmed as protective factors to schistosomiasis in CB. The chance of infection was significantly lower among individuals who had treated public water supply (AdOR=0.3; CI95%=0.1-0.7) and among participants with family history of schistosomiasis (AdOR=0.3; CI95%= 0.1-0.9).

DISCUSSION

The districts of Córrego do Bernardo and Córrego do Melquíades are known as endemic areas for schistosomiasis and despite the fact that 80% of families included in this study have participated in previous surveys along the years, no recent information about the distribution of the disease in these localities has been available. One of the objectives of the present research was to establish a current baseline for future population studies regarding evaluation of programs of control and immune response in people exposed to infection in endemic areas. The study revealed prevalence rates for schistosomiasis of 12.5% in CB and 31.9% in MQ and despite the similarity between the areas, different risk factors to infection with *S. mansoni* were identified in each district. Although a decrease of prevalence over time was noted, showing a reduction from 67.7% in 1990 to 12.5% in 2009 in CB and from 59.8% in 1998 to 31.9% in 2009 in MQ. Even with the investments in disease control, performed by the federal government, municipal and private initiatives, the disease remains a problem in these communities, the infection rates in the area remain considerably high (Webster et al., 1997).

Similar data described by Masaku et al. (2015) indicated high prevalence of *S. mansoni* infection in the study area. Their objective was to determine the prevalence of *S. mansoni* infection and the associated risk factors two years after withdrawal of four years of mass drug administration programme among primary school children. These authors suggested that treatment should be continued in the school children at regular intervals, monitoring and surveillance intensified to ensure interruption of transmission areas. Considering the current prevalence and worm burden of *S. mansoni*, the districts can be considered areas as low CB and moderate MQ schistosomiasis transmission, according the parameters of the Secretary of Health for the State of Minas Gerais (Drummond et al., 2006). As described in other studies carried out in rural areas, the population sample is mainly composed of adult rural workers and elementary school students with a family income ranging from one to two- three minimum wages (Bethony et al., 2001). Concerning the housing, general conditions of the domiciles are very similar in both districts.

The majority of houses do not have public supply of treated water and the principal resources for obtaining water are cisterns and wells, and secondarily, stream water. The use of stream water for recreation and domestic or work activities is quite different between the two districts. A higher percentage of inhabitants in MQ use stream water. Although most people have reported using bathroom, a large number of respondents use also the outdoors for this purpose. This fact points to a necessity of educative measures for the general population, in order to emphasize the importance of changing habits to reduce transmission of schistosomiasis and geo-helminthes. The multivariate analyses allowed the identification of some factors associated with a higher chance of infection and others associated with an absence of infection with *S. mansoni.* Interestingly, the factors identified are different in these districts.

The variable gender is an important risk factor only in CB. Similar to other studies, males presented an increased chance of infection (AdOR=4.6) with *S. mansoni* (Enk et al., 2010; Sayed et al., 2014; Rapoport et al., 2015). Some authors reported that activities in agriculture, often carried out by men in rural areas, result in an increased exposure to infection with the parasite due to prolonged contact with contaminated water (Kloss et al., 2008). However, in the present study, the association of gender and schistossomiasis was independent of other factors as work activities. The differences in the risk for infection with schistosomiasis of these districts require a reflection about the behavioral and work related aspects in the studied areas. It was observed that the proportion of people in MQ, who have cultivated rice in the past, is higher than that in CB. Indeed, the prevalence of the disease is higher in MQ. It is common to find an association between water intensive farming activities and infection with *S. mansoni* due to the permanent contact with contaminated water (Ruganuza et al., 2015). Rice growing activity has been considered a risk factor for infection by other authors but in this study, this association could not be confirmed (Kloss et al., 2008).

In contrast to this previous publication, rice planting is not any more one of the most significant agricultural activities. Nowadays, the cultivation of corn, beans and manioc are the basis of local subsistence agriculture. The use of treated water showed to be a protective factor for infection in CB (AdOR=0.3). On the other hand, in MQ, people who reported using water of cisterns have a greater chance of infection (AdOR=2.1). This association, apparently controversial, can be understood as an indirect measure of poverty in this locality. People who have no access to treated public water usually use water of cisterns, wells or streams. Consistent with this hypothesis, in MQ, all (100%) households that use water from the cisterns do not have access to public supply of treated water. It is known that the precarious socio-economic situation of families associated with the lack of safe water supply and the habit of bathing in streams increase the frequency of contact with potentially contaminated water and consequently the risk of infection with *S. mansoni* (Grimes et al., 2014; Linsuke et al., 2014; Krauth et al., 2015; Ruganuza et al., 2015). Despite of the general low worm burden for *S. mansoni* in both districts, the intensity of infection was significantly higher in MQ than in CB. Some reasons could explain the higher burden of infection in MQ.

First of all, the quality of water seems to be better in CB, because the use of water supply of springs, considered safe water, is greater in CB (41.4% vs 27.6% in MQ). Secondly, the percentage of people who reported the stream to be the final destination for feces is higher in MQ (9.2% vs 1.6% in CB) which increases the probability of contamination of the water and the maintaining of the transmission of the disease. Lastly, the highest percentage of participants in MQ reported the reasons for contact with stream water for leisure (49.4% vs 27.0% in CB), domestic activities (29.2% vs 9.8% in CB) and activities related to work (20.8% vs 10.3% in CB). Several studies have shown a strong relationship between the intensity of infection and the contact with unsafe water, besides repetitive treatment campaigns for schistosomiasis.

A study conducted in Comercinho, Minas Gerais, Brazil, evaluated the effectiveness of the Schistosomiasis Control Program by comparing evaluation conducted in

2005 with previous data of 1981. There was a significant decrease in intensity of infection along the time of follow up. Interestingly, this same study reported increased access to clean water to households (33.7% in 1981 to 96% in 2005) (Sarvel et al., 2011). Furthermore, Barbosa and Barbosa (1998) showed that in State of Pernambuco, Brazil, the intensity of infection increased as the contacts with contaminated water were more frequent. Another indirect indicator for the risk of infection in this study was the frequency of co-infections with helminthes. It was observed that 41.7 and 20.8% of individuals were co-infected in MQ and CB, respectively. However, only in MQ the presence of other helminthes was significantly associated with *S. mansoni* infection (AdOR=4.3). Multiple parasitic infections are common in tropical regions. Many factors can contribute to that, such as, environmental conditions associated with restricted access to safe water, low hygiene standards, poor socioeconomic conditions and predisposition of the individual (Geiger, 2008). Petney and Andrews (1998) reinforce that in schistosomiasis endemic areas, the possibility of co-infection with other helminthes is frequent. Fleming et al. (2006), showed in a cross-sectional study, that 60.6% of individuals presented co-infections with helminthes in an endemic area.

These authors also reported a positive association of infections with hookworm and *S. mansoni*. The knowledge about the transmission of the disease seems to be an important protective factor. In CB people with history of schistosomiasis in the family had less chance to be infected (AdOR = 0.3). This suggests that families in which occurred prior schistosomiasis infection seem to be better informed about the transmission. In MQ, this association could not be identified after adjustment for others variables. About the importance of health education, Schall et al. (1993), demonstrated a reduction of approximately 10.0% in prevalence rate of schistosomiasis one year after practical implementation of health education in public schools on the outskirts of Belo Horizonte, capital of Minas Gerais State. Massara and Schall (2004), showed the importance of health education for the prevention of the disease. According to them, besides practice of health education conducted by teachers or health professionals, informal education is also of great importance in the control of schistosomiasis, once this knowledge and disease prevention are obtained by living with relatives.

Although geographically very close and showing similarities as socioeconomic status and living conditions, this study showed some differences in the patterns of disease transmission between the two districts. Thus, Cardim et al. (2008) claim that the information has an impacting influence in terms of creating and determining differentiated ways to act when facing problems in specific areas. According to our results, the approach to infection control should be different in these two areas. In MQ, showing greater than 25% prevalence, it is recommended treating the largest number of inhabitants older than 5 years. Differently, for CB, where the prevalence rate was 12.5% the recommendation from Brazilian Ministry of Health is to treat only those individuals with a positive result for parasitological examination (Brasil, 2012). However, major investments are needed in MQ with respect to expanding access to public water and education programs for health, to guarantee an efficient control of the disease. Even with the lowest rates, the control of schistosomiasis in CB remains a challenge. Barakat (2013) showed a significant reduction in the prevalence of schistosomiasis in Egypt, in areas geographically close by implementing multifactor approach and not restricting only to the treatment of infected persons.

In this study, investments were applied in improvement of health awareness, social mobilization, snail control within the activities of the primary healthcare system, and environmental sanitation, all together for the effective control of the infection. Cross sectional designs has been applied in different studies with the goal of describing the distribution patterns of diseases. It is fast and inexpensive and can be used to establishing a baseline to future studies. It was particularly useful in evaluating the extension of the problem of each area and in clarifying the related risk factors. Besides its limitations to establish causal relationships, it confirmed previous studies developed in Brazil, indicating that the maintenance of schistosomiasis could be related to different factors in distinct areas, even though geographically close. The high odds ratio and small confidence intervals support the reliability of the results. The low loss of respondents and low no-responses rates ensure the external validity of the results inferred for these areas.

The characterization of these communities could be fairly useful for temporal analyses and reevaluation of resistance and susceptibility to infection in populations differently exposed to the risks of infection by *S. mansoni*. From this study, it can be concluded that the prevalence in CB was estimated in 12.5 and 31.9% in MQ. In CB, males are more likely to be infected while public water supply and family history of infection with *S. mansoni* are characteristics associated with a lower chance of infection. In MQ the characteristics associated with the disease were co-infection with other helminthes and the use of water from cisterns.

ACKNOWLEDGMENTS

We are very thankful to Maria de Fatima Silva, Marlucy Rodrigues Lima, Lilia Cardoso Pires and Wallace Olimpio for technical support.

REFERENCES

Barakat RMR (2013). Epidemiology of Schistosomiasis in Egypt: Travel through Time: Review. J.Adv. Res. 4(5):425-432.

Barbosa CS, Barbosa FS (1998). Padrão epidemiológico da esquistossomose em comunidade de pequenos produtores rurais de Pernambuco, Brasil. Cad Saúde Pública. 14(1):129-137.

Bethony J, Gazzinelli A, Lopes A, Pereira W, Alves-Oliveira LF, Willams-Blangero W, Blangero J, LoVerde P, Corrêa-Oliveira R (2001). Genetic Epidemiology of fecal eggs excretion during *Schistosoma* mansoni infection in an endemic area in Minas Gerais, Brazil. Mem. Inst. Oswaldo Cruz. 96(Suppl): 49-55.

Brasil MS, 2010. Guide to Epidemiological Vigilance, 7th Ed. Ministry of Health, Brasília. p.806.

Brasil MS, 2012. Integrated strategic action plan for the elimination of leprosy, filariasis, schistosomiasis and oncocercosis as a public health problem, trachoma as a cause of blindness and control of geohelmintíases: action plan 2011-2015. Ministry of Health, Brasília. p.104.

Cardim LL, Bavia ME, Ferraudo AS, Carneiro DDMT, Silva MM, Brito VS, Martins MS, Dantas Filho AMS (2008). Schistosomiasis mansoni infection assessment using geotechnologies and multivariate techniques in the municipality of Jacobina, Bahia. Rev. Baiana de Saúde Pública. 32(1):29-42.

Drummond SC, Silva LCS, Amaral RS, Sousa-Pereira SR, Antunes CM, Lambertucci JR (2006). Morbidity of schistosomiasis mansoni in the state of Minas Gerais, Brazil. Mem. Inst Oswaldo Cruz. 101(Supll.1):37-44.

Enk MJ, Lima ACL, Barros HS, Massara CL, Coelho PMZ, Schall VT (2010). Factors related to transmission of and infection with *Schistosoma mansoni* in a village in the South-eastern Region of Brazil. Mem. Inst. Oswaldo Cruz.105(4):570-577.

Farias LMM , Resendes APC, Sabroza PC, Souza-Santos R (2007).

Fleming FM, Brooker S, Geiger SM, Caldas IR, Correa-Oliveira R, Hotez PJ, Bethony J (2006). Synergistic associations between hookworm and other helminth species in a rural community in Brazil. Trop. Med. Int. Health. 2(1):56-64.

Fonseca F, Freitas C, Dutra L, Guimarães R, Carvalho O (2014). Spatial modeling of the schistosomiasis mansoni in Minas Gerais State, Brazil using spatial regression. Acta Tropica.133:56-63.

Fraga LAO, Lamb EW, Moreno EC, Chatterjee M, Dvořák J, Delcroix M, Sajid M**,** Caffrey C, Davies S (2010)**.** Rapid induction of IgE responses to a worm cysteine protease during murine pre-patent schistosome infection.BMC Immunology. 11:56.

Gazzinelli G, Viana IV, Bahia-Oliveira LMG, Silveira AMS, Queiroz CC, Carvalho OS, Massara CL, Fraga LAO, Colley D, Corrêa-Oliveira R (1992). Immunological Profiles of patients from endemic areas infected with *S. mansoni*. Mem. Inst .Oswaldo Cruz, 87(Suppl.IV):139-142.

Geiger SM (2008). Immuno-epidemiology of *Schistosoma mansoni* infection in endemic populations co-infected with soil-transmitted helminthes:present knowledge, challenges, and the need for further studies. Acta Trop.108(2-3):118-123.

Grimes JE, Croll D, Harrison WE, Utzinger J, Freeman MC, Templeton MR (2014). The relationship between water, sanitation and schistosomiasis: a systematic review and meta-analysis. PLoS Negl. Trop.Dis. 4;8(12):e3296.

Hoffman WA, Pons JA, Janer JL (1934). Sedimentation concentration method in schistosomiasis mansoni. Puerto Rico J. public Health, 9:283-298.

Katz NA, Chaves A, Pellegrino J (1972). A simple device for quantitative stool thick smear technique in Schistosoma mansoni. Rev. Inst. Med. Trop.14:397-400.

Kloss H, Correa-Oliveira R, Quites HFO, Souza MCC, Gazzinelli A (2008). Socioeconomic studies of schistosomiasis in Brazil: a review. Acta Trop.108(2-3):194-201.

Krauth SJ, Musard C, Traoré SI, Zinsstag J, Achi LY, N'Goran EK, Utzinger J (2015). Access to, and use of, water by populations living in a schistosomiasis and fascioliasis co-endemic area of northern Côte d'Ivoire. Acta Trop. 149:179-85.

Linsuke S, Nundu S, Mupoyi S, Mukele R, Mukunda F, Kabongo MM, Luz RI, Geertruyden JV, Sprundel MV, Boelaert M, Polman K, Lutumba P (2014). High Prevalence of *Schistosoma mansoni* in Six Health Areas of – Kasansa Health Zone, Democratic Republic of the Congo: Short Report. PLoS Negl. Trop. Dis. 8(12):e3387.

Masaku J, Madigu N, Okoyo C, Njenga SM (2015). Current status of Schistosoma mansoni and the factors associated with infection two years following mass drug administration programme among primary school children in Mwea irrigation scheme: A crosssectional study. BMC Public Health,15:739.

Massara C, Schall VT (2004). A pedagogical approach of schistosomiasis – an experience in health education in Minas Gerais, Brazil. Mem. Inst. Oswaldo Cruz. 99(Suppl 1):113-119.

Pereira WR, Kloss H, Crawford SB, Velásquez-Melendez JG, Matoso LF, Fujiwara RT, Cançado G, LoVerde P, Correa-Oliveira R, Gazzinelli A (2010). *Schistosoma mansoni* infection in a rural area of Jequitinhonha Valley, Minas Gerais, Brasil: analysis of exposure risk. Acta Trop. 113(1):34-41.

Petney TN, Andrews RH (1998). Multiparasite communities in animals and humans: frequency, structure and pathogenic significance. Int. J. Parasitol. 28(3):377-393.

Preliminary analysis of the Information System in the Brazilian Schistosomiasis Control Program, 1999-2003. Cad. Saúde Pública. 23:235-239.

Rapoport AB, McCormick D, Cohen PA (2015). Screening for Schistosoma mansoni and Strongyloides stercoralis Infection Among Brazilian Immigrants in the United States. Open Forum Infect. Dis. 9(1):1-5.

Rowel C, Fred B, Betson M, Sousa-Figueiredo JC, Kabatereine NB, Stothard JR (2015). Environmental epidemiology of intestinal schistosomiasis in Uganda: population dynamics of biomphalaria (gastropoda: planorbidae) in Lake Albert and Lake Victoria with observations on natural infections with digenetic trematodes. Biomed. Res. Int. 2015:11

Ruganuza DM, Mazigo HD, Waihenya R, Morona D, Mkoji GM (2015). Schistosoma mansoni among pre-school children in Musozi village, Ukerewe Island, North-Western-Tanzania: prevalence and associated risk factors. Parasites and Vectors. 8:377Sarvel AK, Oliveira AA, Silva AR, Lima ACL, Katz N (2011). Evaluation of a 25-Year-Program for the Control of Schistosomiasis mansoni in an Endemic Area in Brazil. PLoS Negl. Trop. Dis. 5(3):e990.

Sayed FG, Alsalahy M, Abd-el-Kader MS, Abdalla OH, Ahmed SS (2014). Prevalence of schistosomiasis among patients attending Qena General Hospital over the years 2011 and 2012. J.Egypt Soc. Parasitol. 44(2):489-495.