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Socioeconomic Determinants of Schistosomiasis in a Poor Rural Area in Brazil. Running short title: Socioeconomic Determinants of Schistosomiasis in Brazil

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Abstract

The objective of this paper is to identify and quantify socioeconomic determinants of *S. mansoni* infection in the rural area of Virgem das Graças in Minas Gerais State of Brazil. A cross-sectional study was carried out to examine the prevalence and intensity of schistosomiasis in relation to socioeconomic characteristics of the households. Log-binomial regression analysis was used to examine the data on both the household and individual levels, analyzing the prevalence ratios for the association of schistosomiasis and socioeconomic variables related to the head of the household. Multiple comparisons through mixed effect modeling were used to examine the relationship between intensity of infection (geometric mean egg counts) and different levels of socioeconomic variables, respectively. In the univariate analysis, place of residence, number of persons per room, and lack of motorized transport were associated with schistosomiasis at the household level and age and unsafe water contact at the individual level. Age, unsafe water contact, number of persons per room, household possessions and lack of education of head of household remained significant predictors of schistosomiasis in the multivariable analysis. Only age was significantly associated with intensity of infection of individuals. It is concluded that widespread poverty, the rural environment, and weak socioeconomic differentiation that result in intense contact with infective water appear to minimize the protective effect of piped water supply and other socioeconomic parameters on schistosomiasis found in other studies. The potential role of socioeconomic development in conjunction with schistosomiasis control is described and areas for further studies are identified.

Keywords

Schistosoma mansoni; socioeconomic factors; rural environment; Brazil

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1. Introduction

There is considerable evidence that socioeconomic conditions are often strongly associated with schistosomiasis occurrence. This relationship was first described in detail by Farooq et al., (1966) in Egypt and since then by studies in different endemic areas (Rosenfield, 1990; Yi-Xin and Manderson, 2005). In Brazil, the role of socioeconomic factors in *Schistosoma mansoni* transmission has been examined by studies in rural areas (Coura-Filho et al. 1994; Lima e Costa, 1991; Silva et al., 1997) and urban (Barreto,1991 ;Kloetzel, 1989; Lima e Costa et al., 1987; Ximenes et al., 2003). However, only Ximenes et al. (2003) studied the relationship between socioeconomic determinants and schistosomiasis distribution in depth, using non-causal determinism, which posits that socioeconomic conditions determine and operate through various conditioning factors, or intermediate mechanisms, not necessarily in a causal manner. They found a strong relationship between socioeconomic variables and schistosomiasis in a town in northeast Brazil, but their findings are not applicable to rural areas, where the generally weaker socioeconomic differentiation and more widespread schistosomiasis risk present a different epidemiological setting. Socioeconomic studies are still called for as Brazil is still in need of an adaptable national schistosomiasis control methodology that considers local differences in disease ecology (WHO, 2001).

The study area, Virgem das Graças, is located in the *S. mansoni*-endemic area of northern Minas Gerais State and shares many physical and socioeconomic environmental features with the larger endemic region of northeastern Brazil, of which the study area forms part of the southern fringe. They include a semiarid climate with unreliable rainfall, marginalized subsistence farming, widespread poverty, high rates of rural-urban migration**,** and many communities with hyperendemic schistosomiasis. Partly due to its isolation, the Virgem das Graças population had never been treated for schistosomiasis by the government program. The hypothesis of this study is that the distribution of schistosomiasis in the Virgem das Graças population is determined by socioeconomic factors rather than occurring at random. Due to the high degree of household aggregation of schistosomiasis reported by Bethony et al. (2001) from a nearby rural study area and by Ximenes et al. (2003) in a town in northeastern Brazil, the role the household as a social organization and in economic decision making (Berman et al., 1994; Kroeger, 1985), particular emphasis in this study was given to the household level.

This study constitutes part of a broader epidemiological and immunological project. Malacological surveys revealed the high transmission potential of the 11 types of natural and manmade snail habitats studied by Kloos et al. (2004). Concomitant water contact studies carried out in three representative localities in the study area that used multiple methodologies indicate high exposure risk levels for the study population (Kloos et al., in press).

2. Materials and methods

2.1.Study area, economy and population

Virgem das Graças is a 60 square km large rural area of Ponto dos Volantes Municipality, located in the Jequitinhonha Valley in northern Minas Gerais State, 120 km north of the town of Teófilo Otoni. According to our census survey in 2001, 589 people (48.2% males and 51.8% females) lived in the study area in 141 households. Each resident present at the time of the survey and each household was registered and given unique personal identification numbers (PID) and household identification numbers (HHID). The study population lived on dispersed homesteads in the area’s 4 hamlets and a nucleated central village. All settlements are located in close proximity of streams in 4 valleys. The nearest medical services are 30 km distant over a rough dirt road. The 4 hamlets (Cardoso 1, Cardoso 2, Cardoso 3, and Sussuarana) depend on the streams, canals, wells, springs and earthen dams and the central village of Taboca on a safe, piped spring source for most of their domestic water needs. The prevailing mixed agriculture, characterized by cultivation of maize and manioc as staple foods and cattle raising, is of the subsistence type. Remittances from migrant labor, small-scale sale of manioc and milk, and pension payments constitute the main sources of income.

Biomphalaria glabrata, the local snail intermediate host, is established in all 11 aquatic habitats (streams, swamps, springs, stream overflow and seepage ponds, canals, dams, fishponds, irrigation ponds, cattle ponds, and water tanks) studied in Virgem das Graças. *S. mansoni*-infected snails were found in several streams, canals, swamps and shallow wells, and in 1 spring, irrigation pond and cattle pond each, indicating widespread transmission in both the household environment and agricultural areas (Kloos et al., 2004). Thus all water contacts with these 11 habitats were classified as unsafe and contacts with the central piped water and piped water from springs as safe.

Every person 2 years and above residing in the study area at the time of the household survey was included in the study. The exclusion criteria used in selecting the study population were people who resided in the area only on weekends, people absent at the time of the stool and questionnaire surveys, and people refusing to participate. Five hundred fifty-nine persons living in 136 households were included in the study, excluding 5 households and 30 persons absent or residing in the study area only on weekends (n=25) or refusing to be interviewed (n=5). Informed consent was obtained using a standardized form approvaed by the National Ethics Committee of Brazil and the Internal Review Board of the State University of New York at Buffalo.

2.2. Selection of the socioeconomic variables

Due to the absence of information on social structure and social stratification in the study area, we selected two sets of socioeconomic variables. The first set describes the study population in regard to its position in the production process. The second set characterizes its consumption patterns. This information, which is important in determining the position of the family and individuals in the production process (Ximenes et al., 2003), was related primarily to the head of the household. Considering the conceptualization of the household as a social and residential unit (Berman et al. 1994) and our previous studies in another rural area in Minas Gerais (Bethony et al., 2004), we assumed that all study members in a given household belonged to the same socioeconomic group as the household head due to the fact that they share in the production and consumption process. Two socioeconomic variables were used to characterize the population in regard to the production process: 1) type of occupation of head of household, with three subgroups (agriculture, all other occupations, and retired and handicap persons) and 2) family income in Reais (1 Real was about $US 0.30 in 2001) (three income categories constituting multiples of the Brazilian minimum wage). Six variables were selected that are related to patterns of consumption: education (two levels: no formal education and some education (grades1 or higher**)**, quality of housing (2 levels: poor and good quality, based on construction material for walls and roof, and type of floor), household possessions (2 categories), water supply and accessibility (3 categories), latrine presence and type (3 categories), and frequency of individual contact with potentially infective water during an average month for all water contact activities except swimming and fishing (1 year) (2 categories). This classification was considered appropriate in the subsistence agricultural area of Virgem das Graças study area, which lacks the socioeconomic diversification and most public services of Brazilian towns and thus does not warrant the more elaborate classification developed by Ximenes et al., (2003). Moreover, the variables electricity and household appliances, used by Ximenes et al. (2003), were examined only peripherally since electricity in Virgem das Graças, like in other rural areas of Brazil, is provided by the government and the routing of lines left most households located at some distance from the lines without power, although they may be able to afford it. Thus only Type of motorized transport was included in the category Household possessions for final analysis. Similarly, the generally poor housing conditions, predominance of individual home-built water supply systems and lack of community sewage system called for simpler classifications of house quality, water supply and sanitation levels than the more elaborate groupings by Ximenes et al. (2003).

At the time of this study, the national schistosomiasis control program had not yet been implemented in Virgem das Graças. The difficulties to reach the distant clinics over a rough road coupled with poverty prevented many people from seeking medical care. Thus no questions about previous schistosomiasis treatment were included in the questionnaire.

2.3. Socioeconomic and water contact survey

Four university undergraduate students (1 male and 3 females) trained in interview surveys in rural areas and the principal author carried out questionnaire surveys in all households in the study area in 2001, using a pre-tested questionnaire. All households and inhabitants were given unique code numbers during the initial census. Due to the dominance of males in income generation in Virgem das Graças and the generally more intimate knowledge females have of household-related activities, efforts were made to include both male and female household heads during interviews. Female heads of households were defined as the spouse of the household head or the women who headed the household in the absence of a male head.

Information on household water contact behavior was obtained by asking all household members 8 years and older individually about any contacts they had with the streams and other infective sources for domestic and most occupational and recreational purposes during the 7 days preceding the survey or for rare and seasonal activities (swimming, cleaning streams or fishing) for mean weekly contact frequency during the preceding 12 months using a pre-tested form (Gazzinelli et al., 2001). All water contacts were classified as either safe (piped supply in the central village and protected springs) or unsafe (all streams and all other unprotected sources), based on the presence/absence of *Biomphalaria* snails found during 4 seasonal surveys in different habitats (Kloos et al., 2004).

2.4. Data analysis

The schistosomiasis data contained information on 559 individuals in 136 study households. We were interested in exploring both prevalence and intensity of schistosomiasis, where intensity was measured by the egg count. A histogram of the egg counts among the infected individuals showed a severely right skewed distribution; therefore, a log transform of the egg counts was used in order to obtain normality. We analyzed the data considering both individual and household-level variables. Several predictors were unique to the individual, such as age and sex, while several others were common to everyone in the household, such as quality of housing or water supply. There were also variables where individual-level data were available, but it was believed that the data for the head of household better reflected the socioeconomic status of all members of the household, such as education or occupation.

We modeled the presence of schistosomiasis using univariate and multivariable log-binomial regression in order to explore the relationship between socioeconomic variables and infection. Schistosomiasis previously has been linked to environmental factors, such as water supply, that tend to be common to all members of a household (Bethony et al., 2001, 2004; Coura-Filho et al., 1996, Ximenes et al., 2003; Lima e Costa et al., 1991). Because multiple members of households were sampled, schistosomiasis infection among members of the same household may not have been independent events. In order to account for this possible dependency, we used generalized estimating equations with an independent correlation matrix (Liang and Zegler, 1986). The generalized estimating equations were used to obtain standard errors of the parameter estimates that were empirically-corrected for the clustering of the data by household. The binomial distribution and log link function were used in the regression analysis. We used the prevalence ratio to estimate risk of infection because schistosomiasis is not a rare disease in Virgem das Graças. The prevalence ratio (PR) produced by the log-binomial model can be more easily interpreted than the prevalence odds ratio produced by logistic regression. (Skov, 1998) First, we looked at models with a single predictor in order to determine the univariate prevalence ratios for the demographic, social and residential, economic, housing and household possession, and water supply and sanitation variables. A generalized score statistic was computed in order to determine the overall significance of each variable, while the confidence intervals reflect significant differences between variable levels. The level thought to be associated with the least amount of risk for developing schistosomiasis was chosen as the reference level.

In developing the multivariable model we began by assessing several proposed interactions, adding each interaction to the full model containing all of the predictors presented in the univariate analysis. While none of these interactions were significant, the parameter estimates seen in the main effects indicated possible problems with multicolinearity. The estimates produced for a small number of variables resulted in prevalence ratios counterintuitive to the general understanding of the proposed risk factors. One variable, non-significant in the univariate analysis, was removed from the model building process, which then proceeded using a forward model building technique. Starting with a model containing simply an intercept, variables were added to the model one at a time based upon significant contribution relative to the contribution of the other variables. Those variables not entered into the multivariable model as significant predictors for schistosomiasis were assessed as confounders.

After carrying out the univariate and multivariable analyses, we examined the intensity of infection by each of the predictors included in the final multivariable model. We examined the intensity of infection based on the log-transformed geometric mean egg counts among those individuals infected with schistosomiasis. Using a mixed model with an exchangeable correlation matrix for household clusters, we calculated a geometric mean and confidence interval for each level of the predictors included in the multivariable model. This was achieved by modeling the $\log_{10}$ of the mean egg counts of each individual versus the covariates of interest, obtaining the least squares mean and confidence interval, and then transforming the estimates back to the original scale of the egg counts. An overall F-test of the mixed model was used to determine whether any differences in the mean log egg counts existed among the covariate levels. The pair-wise differences in means across all possible combinations of the covariate levels were calculated and assessed for significance using a Tukey multiple comparison adjustment (Westfall et al., 1999). All analyses were completed in SAS (version 9.1).

2.5. Parasitological methods

A cross-sectional parasitological survey was carried out in 2001. All study households and members were given 3 plastic containers for fecal samples. Individuals in the household who were not included in the study also received containers. Containers were labeled with the participant's full name, age, personal identification number (PID) and household identification number (HHID). Participants were instructed to deposit 1 fecal sample per day into each container and return the containers immediately to 1 of several collection points, where the samples were stored at 4°C. Fecal samples returned later than 48 hours after the distribution date were not accepted, and new containers were issued. Slides were prepared within 24 hours of collection using the Kato-Katz thick smear technique (Katz et al., 1972), with 2 slides being prepared from each day's stool sample, for a total of 6 slides per individual. Three laboratory technicians carried out the microscopic examination at a field laboratory in Virgem das Graças.

3. Results

Of the 559 study members in the 136 households, 47.2% were males and 52.8% females. The population age ranged from 2 to 95 years (mean 30.9, SD 22.4, and median 24.0 years). The extreme age groups, <14 years and >65 years, represent 32.6% and 8.1% of the entire population, respectively.

The overall geometric mean egg count was 52.3 eggs per gram of feces, while the overall prevalence of infection was 58.7%. Prevalence tends to follow intensity of infection, peaking in the 15–29 year old age group across both genders, with relatively high egg counts in the below-14 age group and low egg counts in individuals 45 years and older.

We conducted a univariate analysis of the probability of *S. mansoni* infection among levels of various potential risk factors, including socioeconomic, demographic and behavioral characteristics of household heads and individual family members. Of the demographic variables considered, we found a significant association between schistosomiasis infection and age group, but not gender. The most notable results occurred in the 15–29 and 30–44 year old age groups, where the prevalence of schistosomiasis was 1.6 (95% CI = 1.2–2.0) and 1.4 (95% CI =1.1–1.8) times the prevalence in the childhood referent group (Table 1). Place of residence was also significantly associated; the prevalence of infection in a rural area was 1.3 (95% CI = 1.1–1.6) times the prevalence of infection in VDG (Table 1). The education level of the head of household was also significant. The prevalence of infection for those individuals living in a household where the head had no education was 1.3 (95% CI = 1.0–1.6) times the prevalence where the head of household had some education (Table 2). Neither of the variables chosen to represent the household's economic position, the head of household's occupation nor family income, was significantly associated with infection (Table 2). Of those variables summarizing housing conditions, the number of persons per room was a significant predictor at the univariate level. Those individuals living in a home with more than 1.3 persons per room had a prevalence ratio of 1.3 (95% CI = 1.1–1.6) when compared to those living in a home with less than 0.60 persons per room. Household possessions was also significantly related to schistosomiasis, with the prevalence among those without a motorbike or car 2.0 (95% CI = 1.3–3.0) times greater than individuals with at least one of these two modes of transportation. House ownership, land ownership, and the quality of housing index were not significant predictors (Table 2). Of the water supply and sanitation variables, the water supply and accessibility index and sanitation were not significantly associated with schistosomiasis infection in the multivariable model. However, the prevalence ratio among those individuals with unsafe water contact was 1.7 (95% CI = 1.3–2.3) times greater than the risk for those individuals not reporting unsafe water contact (Table 2).

Table 3 shows the multivariable model for schistosomiasis infection. Several plausible interactions were assessed at the beginning of the model building procedure with all possible predictors included in the model, such as place of residence and head of household occupation, or place of residence and unsafe water contact, but none of these interactions were significant. Upon fitting the full model to examine these interactions, we saw evidence of problems with multicolinearity. While water supply was not significantly associated with schistosomiasis in the univariate analysis, the estimates in the full model were showing a protective effect for unsafe water supplies. A similar result was observed for family income. In order to reduce the effects resulting from high multicolinearity, the water supply variable was not considered in the model building process for the multivariable model. This was not thought to be problematic since the variable was not significantly associated with schistosomiasis on the univariate level. The sequential forward modeling process proceeded, considering each variable for inclusion in the model at each step, with the most significant variable controlling for all others already included in the model being added at each step. Then, confounding was assessed by adding each of the variables considered in the univariate analysis but not included in the multivariable analysis to the selected model. The variables age group, unsafe water contact, household possessions, number of persons per room, and education of the head of household remained significantly associated with infection when controlling for the other variables in the model. Place of residence and head of household occupation were marginally significant when controlling for the other five significant predictors and were retained in the final model because they have been shown to be associated with schistosomiasis in previous studies [Barreto, 1991;Ximenes et al. 2003]. Holding constant the other predictors entered into the model, age and *S. mansoni* infection were highly associated in the age groups 15–29 and 30–44 years when compared with the referent group. The individuals in both those groups were 1.3 (95% CI = 1.1–1.5) times more likely to be infected when compared with the group of 0–14 years. The other variables or variable levels showing a significant or marginally significant association with infection when compared with the referent level were unsafe water contact (PR = 1.5; 95% CI = 1.2–1.9), rural place of residence (PR = 1.1; 95% CI = 1.0–1.2), households with more than 1.33 persons per room (PR = 1.2; 95% CI = 1.0–1.3), having a head of household with no education (PR = 1.2; 95% CI = 1.1–1.4), having the head of household work in other occupations beside agriculture, compared to being retired and handicapped (PR = 1.3; 95% CI = 1.1–1.6), and living in a household that did not possess either a car or a motorbike (PR = 1.9; 95% CI = 1.3–2.6). A possession index primarily consisting of electric appliances was also created but was not included in the final analysis because the electricity distribution among households was a governmental factor rather than a socioeconomic factor. A preliminary univariate analysis of this index (data not shown in Table 2) showed that those persons living in a household with no forms of transportation or appliances had a significantly higher prevalence of infection than individuals living in houses with cars, refrigerators or motorbikes (PR = 1.7 (95% CI = 1.2–2.3); those individuals living in a household without a car, refrigerator or motorbike but having a TV, VCR, and/or a washing machine also had a relatively higher prevalence of schistosomiasis (PR = 1.5; 95% CI = 1.0–2.2).

Since all variables in the multivariable model were considered potential risk factors for *S. mansoni* infection, egg counts (log transformed) were compared across each category of those variables. Table 4 shows geometric mean egg counts and the 95% confidence interval (CI) for each level of the selected variables. Geometric mean egg counts were significantly associated with age group (F-statistic=8.94, $p < 0.001$) and marginally significant with number of persons per room (F-statistic=2.41, p=.0708). With the exception of the comparison between 30–44 year olds and above 65 year olds, the Tukey multiple comparison procedure indicated that geometric mean egg counts among those age groups below 45 years were significantly higher than those for age groups 45 years and older. The 45–64 and above-65 age groups had similar prevalence and egg counts (tables 3 and 4). The geometric mean egg counts among those infected individuals living in households with 1.33–4.00 persons per room were greater than among those individuals living in households with less than 0.6 persons per room (Table 4). The overall statistics did not indicate any significant differences in the geometric mean egg counts with water contact, head of household education, head of household occupation, place of residence, or household possessions.

4. Discussion

This study in an impoverished rural area within the region of high endemicity of schistosomiasis in Brazil shows a weak to moderate relationship between most socioeconomic indicators and infection. Education of head of household, household possessions, and number of persons per room were the major socioeconomic predictors of schistosomiasis occurrence and occupation of head of household became marginally significant in the multivariable model when included with education. The association of these household-based variables with *S. mansoni* infection corroborates the findings by Bethony et al. (2001, 2004), who pointed out the importance of the household in water contact behavior and transmission. Absence of a significant association between the widely used socioeconomic indicators household income, occupation (especially agriculture), and water supply and sanitation is in contrast with the findings of other investigators in Brazil (Bethony et al., 2001; Coutinho et al., 1997; Coura-Filho et al., 1994; Silva et al., 1997). The individual-level variables age and unsafe water contact, the strongest predictors of *S. mansoni* infection, were also identified by other studies in Brazil (Barreto, 1991; Lima e Costa et al., 1991; Barbosa et al., 1998).

Our findings may be attributed to the poor socioeconomic environment of Virgem das Graças. The widespread poverty and the rural way of life put the whole community at risk of infection, a situation that was also reported by Moza et al. (1998) from a poor rural village in northeast Brazil. They attributed the lack of a socioeconomic effect on the lack of socioeconomic diversity in their study community that conferred fairly uniform exposure risk to the whole population. A similar situation prevails in Virgem das Graças. All socioeconomic groups reported high rates of contact with the streams, swamps and other potentially unsafe water bodies. Furthermore, households and individuals belonging to different income, occupational and educational groups all tend to farm, must cross the streams and flooded areas when traveling on foot within and outside the community, and use stream water when safe supplies in the central village are insufficient and periodically unavailable. Especially during high-use periods in the afternoons and at times of supply pipe obstruction, households revert back to using stream water for their domestic needs. That the relatively weak role of socioeconomic variables in Virgem das Graças may be due to the particular socioeconomic/ecological setting of this area is also suggested by Lima e Costa et al. (1998), who showed that the role of different socioeconomic risk factors in *S. mansoni* infection varies considerably among rural Brazilian communities, depending to a large extent on their economic situation, migratory patterns, domestic water supplies, and control programs. Ximenes et al. (2003), by contrast, reported stronger relationships between socioeconomic indicators and *S. mansoni* infection in urban areas in northeast Brazil, where marked differences in socioeconomic level and the availability of social infrastructure resulted in highly variable risk of infection. Thus, although safe water supply is generally known to reduce exposure risk in schistosomiasis-endemic areas (Barbosa et al., 1971; Esrey et al., 1991; Jordan et al., 1982; Noda et al., 1997), the predominantly agricultural way of life and extensive poverty in Virgem das Graças facilitate the continuous use of the snail-infested water sources by the total population. The sharp drop in both *S. mansoni* in prevalence and egg counts in the 45–64 group and persistence of low rates in the above-65 group are in contrast to the pattern of continuing high exposure into old age in the study population and will be examined in a separate paper.

The improvements made by individual households in the 4 rural hamlets represent the lowest level of water supply upgrade according to the water development typology developed by White et al. (1972). Most households which have individual spring-fed piped supplies in the rural areas and some in the central village of Virgem das Graças continue to use the streams for washing clothes, bathing on the way home from work in the fields, playing, fishing and when crossing (Kloos et al. in press), also noted in two other rural areas in Minas Gerais State (Gazzinelli et al., 1998, 2001). Other reasons for the continued use of unsafe water supplies include availability of larger water quantities in the streams, recreational and social needs, and periodic blockage of pipes or breakdown of the rudimentary distribution systems. In other Brazilian rural areas as well, the provision of piped water supply tended to reduce but not eliminate exposure risk during domestic activities (Kloos et al., 2001; Silva et al., 1997). Similarly, the relatively weak sanitation effect in Virgem das Graças is also due to conditions of rural living which impede the use of latrines and absence of a sewage system. This situation perpetuates the contamination of snail habitats by schistosome eggs, reported from most endemic rural areas in developing countries (Jordan et al., 1993).

The findings of this study have several implications for schistosomiasis control in rural areas. First, the fact that *S. mansoni* infection was not significantly associated with most socioeconomic variables due to widespread poverty indicates that only broadly based rural development that reduces the dependence of the population on the streams and other unsafe water sources for domestic, recreational and occupational purposes and reduces fecal contamination of snail habitats may benefit the total population. This is also indicated by the experiences of significant achievements in controlling schistosomiasis in Japan, Venezuela, and China, all of which made significant achievements in controlling schistosomiasis as a result of socioeconomic development (Ximenes et al., 2003). Broadly based socioeconomic development augmented by basic public health interventions that includes the provision of an adequate piped water supply, sanitation facilities and health education may thus benefit schistosomiasis control programs in this rural area. Ximenes et al. (2003) called for the implementation of a national policy facilitating access to formal education, land and safe water sources towards permanent control of schistosomiasis. Katz (1998), reviewing the national schistosomiasis situation and control program and noting the many setbacks experienced in the use of the conventional snail control and chemotherapy programs, identified water supply, sanitation, sewage facilities, and health education as the “real tools” for controlling this disease in the long term.

Second, two variables, number of persons per room and ownership of motorized vehicles may be useful indicators of schistosomiasis risk in a subsistence economy. Significant associations between house quality parameters and schistosomiasis were reported by Lima e Costa (1991) in a rural area and by Kloetzel (1989) and Ximenes (2003) in urban communities. Our finding that number of persons per room, the only significant housing-linked predictor of schistosomiasis, was also significantly associated with age group but not with household income, indicates a predominantly demographic or density rather than socioeconomic influence.

Lastly, the centralized water supply system in the central village on schistosomiasis constitutes an encouraging achievement in this impoverished community. This water supply was developed in the 1980s under the leadership of the local Catholic priest and entirely through community contributions of labor and materials. Community-based initiatives and participation in water supply development and management with municipal rather than federal or state government assistance have been practiced for decades in Brazilian towns and have become more common in recent years in rural communities (Coura-Filho et al., 1996; Kloos et al., 2001). WHO (1993) is encouraging this trend as an effective approach to strengthening community responsibility and improvements of water supplies.

This study points out the need for further studies to identify additional meaningful socioeconomic parameters and epidemiological patterns in other poor rural communities with different ecological, demographic and socioeconomic characteristics.

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Table 1

Prevalence ratios (PR) and 95% confidence intervals (CI) for schistosomiasis infection of individuals/heads of households according to demographic variables

Variable	No. of individuals	PR	95% CI
Sex			
Female	295	0.95	(0.82 –1.10)
Male	264	1.00	
Generalized score statistic = 0.47, df = 1, p = .4916			
Age group			
> 65	45	1.05	(0.70 – 1.56)
45 – 65	116	1.02	(0.78 – 1.34)
30 – 44	86	1.40	(1.12 – 1.76)
15 – 29	130	1.56	(1.23 – 1.98)
< 14	182	1.00	
Generalized score statistic = 24.20, df = 4, p < .0001			
Place of residence, head of household			
Rural Area	273	1.29	(1.06 – 1.57)
VDG	286	1.00	
Generalized score statistic = 6.60 df = 1, p = .0102			

Table 2

Prevalence ratios (PR) and 95% confidence intervals (CI) for schistosomiasis infection of individuals/heads of households according to socioeconomic and exposure variables

Variable	No. of individuals	PR	95% CI
Education, head of household			
None	325	1.26	(1.03 – 1.55)
Some	234	1.00	
Generalized score statistic = 5.14, df = 1, p = .0234			
Occupation, head of household			
Agriculture	293	1.14	(0.90 – 1.45)
All other occupations	122	1.10	(0.82 – 1.48)
Retired or handicapped	144	1.00	
Generalized score statistic = 1.26, df = 2, p = .5329			
Family income			
0 ≤ income < 180	132	1.16	(0.92 – 1.46)
180 ≤ income < 360	239	0.99	(0.78 – 1.25)
360 ≤ income < 3000	188	1.00	
Generalized score statistic = 2.13, df = 2, p = .3443			
House ownership			
No	95	1.18	(0.98 – 1.44)
Yes	4644	1.00	
Generalized score statistic = 2.31, df = 1, p = .1287			
Land ownership			
No	389	1.00	(0.80 – 1.24)
Yes	170	1.00	
Generalized score statistic = 0.00, df = 1, p = .9740			
Quality of housing			
Poor	167	1.15	(0.96 – 1.38)
Good	392	1.00	
Generalized score statistic = 2.10, df = 1, p = .1472			
Number of persons per room			
1.33 ≤ x < 4.00	136	1.33	(1.07 – 1.63)
0.80 ≤ x < 1.33	167	0.99	(0.76 – 1.28)
0.60 ≤ x < 0.80	123	0.78	(0.59 – 1.03)
0.14 ≤ x < 0.60	133	1.00	
Generalized score statistic = 12. 92, df = 3, p = .0048			
Household possessions			
No car or motorbike	508	1.96	(1.29 – 2.98)
Car and/or motorbike	51	1.00	
Generalized score statistic = 8.43, df = 1, p = .0037			
Water supply and accessibility			
Some form of unsafe water(either stream and/ or unprotected water and/or an unprotected spring and/or a well)	140	1.07	(0.80 – 1.43)
Safe water supply(no stream, no unprotected water, no unprotected spring, and no well), but lacking some combination of water tank, basin, faucet, and/or shower	257	1.03	(0.82 – 1.30)
Safe water supply(no stream, no unprotected water, no unprotected spring, and no well), and has a water tank, a basin, a faucet, and a shower	162	1.00	
Generalized score statistic = 0.20, df = 2, p = .9034			
Unsafe water contact			
Yes	408	1.70	(1.28 – 2.25)
No	141	1.00	
Generalized score statistic = 15.16, df = 1, p < .0001			
Sanitation			
No latrine	81	1.29	(0.96 – 1.73)
Pit latrine	325	1.09	(0.85 – 1.40)
Flush latrine	153	1.00	
Generalized score statistic = 2.56, df = 2, p = .2779			

Table 3

Multivariable model of the association between demographic, behavioral, socioeconomic and residential variables and schistosomiasis infection

Variable	PR	95% CI
Age group*		
< 14	1.00	
15 – 29	1.31	(1.13 – 1.53)
30 – 44	1.31	(1.13 – 1.51)
45 – 65	0.95	(0.78 – 1.16)
> 65	1.02	(0.70 – 1.49)
Unsafe water contact*		
Yes	1.48	(1.18 – 1.87)
No	1.00	
Household possessions*		
No car or motorbike	1.85	(1.31 – 2.60)
Car and/or motorbike	1.00	
Number of persons per room*		
$1.33 \leq x < 4.00$	1.16	(1.04 – 1.29)
$0.80 \leq x < 1.33$	1.00	(0.95 – 1.06)
$0.60 \leq x < 0.80$	0.87	(0.72 – 1.05)
$0.14 \leq x < 0.60$	1.00	
Education, head of household*		
None	1.19	(1.05 – 1.35)
Some	1.00	
Occupation, head of household		
Agriculture	1.12	(0.92 – 1.37)
All other occupations	1.30	(1.07 – 1.58)
Retired or handicapped	1.00	
Place of residence		
Rural	1.08	(0.99 – 1.18)
VDG	1.00	

*Statistically significant

Table 4

Intensity of schistosomiasis infection of individuals expressed as geometric mean of *S. mansoni* eggs per gram of feces, by predictors in the multivariable model.

Variable	No. infected individuals	Mean egg counts (log10)	Geometri c mean	95% CI	Tukey Grouping*
Age group					
< 14	89	1.83	67.99	(47.23 – 97.88)	A
15 – 29	99	1.91	80.88	(58.29 – 112.23)	A
30 – 44	59	1.80	63.40	(42.58 – 94.42)	A, B
45 – 65	58	1.36	23.06	(15.45 – 34.43)	C
> 65	23	1.40	24.87	(13.29 – 46.53)	B, C
Overall F-statistic = 8.94, num df = 4, den df = 100, p < .0001					
Unsafe water contact					
Unsafe contact	270	1.66	46.16	(28.54 – 74.67)	A
No unsafe contact	55	1.74	54.94	(42.79 – 70.55)	A
Overall F-statistic = 0.49, num df = 1, den df = 24, p = .4893					
Household possessions					
No car or motorbike	312	1.72	52.19	(41.28 – 65.99)	A
Car and/or motorbike	16	1.72	52.81	(21.41– 130.27)	A
Overall F-statistic = 0.00, num df = 1, den df = 115, p = .9800					
Number of persons per room					
1.3334 ≤ n < 4.00	103	1.93	85.79	(53.76 – 136.90)	A
0.80 ≤ n < 1.3334	94	1.74	54.49	(35.70 – 83.15)	A, B
0.60 ≤ n < 0.80	55	1.68	48.08	(29.44 – 78.54)	A, B
0 ≤ n < 0.60	76	1.57	37.49	(25.04 – 56.12)	B
Overall F-statistic = 2.41, num df = 3, den df = 113, p = .0708					
Education, head of household					
None	209	1.71	50.73	(37.85 – 70.00)	A
Some	119	1.74	54.53	(38.02 – 78.20)	A
Overall F-statistic = 0.09, num df = 1, den df = 115, p = .7587					
Occupation, head of household					
Agriculture	179	1.76	58.05	(42.46 – 79.37)	A
All other occupations	72	1.82	65.71	(40.59 – 106.38)	A
Retired/handicapped	77	1.55	35.28	(22.77 – 54.66)	A
Overall F-statistic = 2.25, num df = 2, den df = 114, p = .1105					
Place of residence					
Rural	181	1.80	62.81	(46.44 – 84.97)	A
VDG	147	1.62	41.70	(29.78 – 58.37)	A
Overall F-statistic = 3.22, num df = 1, den df = 115, p = .0753					

* The mean egg counts for various levels of each variable were tested for significant differences. Those levels, within a variable, showing no statistically significant difference display the same letter. Those levels that are significantly different do not have the same letter.