EVALUATION OF AN IMPROVED APPROACH USING RESIDENCES OF SCHISTOSOMIASIS-POSITIVE SCHOOL CHILDREN TO IDENTIFY CARRIERS IN AN AREA OF LOW ENDEMICITY

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Abstract. School children were used as indicators for the identification of schistosomiasis-positive family members in a area of low endemicity. This study was designed to improve current schistosomiasis control programs by applying this strategy to identify schistosomiasis-positive individuals in a more efficient way. The initial prevalence among school children was 8.6%. However, the prevalence among the family members of these school children increased to 15.5%. In contrast to these findings the prevalence in family members of schistosomiasis-negative school children was 3.8%. Although the applied methodology showed a relatively low sensitivity (50.0%), the high negative predictive value (87.7%) indicates that a few positive family members of school children with a negative stool result will be missed. This shows that this method of evaluation could be a strategy for a more efficient and cheaper identification of schistosomiasis-positive individuals in areas of low endemicity.

INTRODUCTION

There is evidence that prevalence and worm burden have decreased significantly since the introduction of the Special Program for Schistosomiasis Control in Brazil during the 1970s.[1–3] Given this fact, new objectives need to be defined transferring from control programs designed for morbidity reduction to strategies for transmission control. Moreover, in areas of low endemicity, the exact definition of the prevalence of a population, as well as the identification of asymptomatic carriers, becomes unviable because a large amount of unnecessary stool examinations has to be carried out to find a relatively small number of infected individuals. In this special epidemiologic setting, screening of the whole population turns out to be very costly, time-consuming, and not sustainable on a large scale. Therefore, the identification of defined groups at risk in areas with prevalence rates less than 20% is essential to maintain the viability of control strategies. As described by the World Health Organization,[4] school children represent one of the most important risk groups. The advantages of screening school children are the low costs, good acceptance and compliance, and easy identification and localization of the individual.[5] Nevertheless, the fraction of adult asymptomatic carriers will be missed by this approach. In areas of low prevalence, this fraction of the population plays an important role in maintaining the transmission of the disease.

Since schistosomiasis-positive school children are living in an environment where infection with *Schistosoma mansoni* is more likely, one can assume that members of their families are at a similar risk, which justifies the inclusion of these family members into the screening process. An important characteristic for schistosomiasis transmission is a set of household and leisure activities related to water use. Such activities may be related with the infection foci, leading to the spread of risk factors for the family members.[6,7] The purpose of this study was to improve current schistosomiasis control programs by using this strategy to identify schistosomiasis-positive individuals in a more efficient way.

MATERIALS AND METHODS

Study area. Jaboticatubas (19°31′S, 43°44′W) is a county in the outer metropolitan region of Belo Horizonte, Minas Gerais, Brazil. The town is well known as the capital of schistosomiasis because it attracted huge media attention in the 1960s. The area is characterized by rich water sources such as waterfalls, brooks, and rivers, which enhance the natural beauty of the region. The national park Parque Nacional da Serra do Cipó, half of which is situated in this area, is visited by tourists mainly during holidays and weekends. Jaboticatubas has an area of 1,113 km², is 64 km from Belo Horizonte, and has a population of 13,530 inhabitants (Brazilian Institute for Geography and Statistics, 2000), of which 7,116 (52.6%) are in the urban area and 6,414 (47.4%) are in the rural areas. The local economy is based on agriculture and cattle breeding.

Based on reports of the National Health Foundation in the 1990s, the district of São José de Almeida and the localities of São José da Serra and Cipó Velho, which are situated north of Jaboticatubas, were chosen for the study. These areas have schistosomiasis prevalences greater than 15% in the most recent reports. All four schools in these areas were included in the study, which was conducted between 2001 and 2003.

Parasitologic survey. A cross-sectional study was carried out to identify the prevalence of *S. mansoni* among the school children in four schools. Two were located in the district of São José de Almeida, one in the locality of São José da Serra, and one in Cipó Velho. Nearly all of the school age children (99%) living in the study area participate regularly in classes. A total of 1,533 students were enrolled in the four schools in 2001. After explaining the purpose of the project, each student received a stool collection container labeled with the following information: student name, registration number, school year, and teacher's name. After distribution, the containers were given to the teachers up to three days later. The stool samples were then sent to the laboratory to be processed

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and examined using two slides for each sample according to the Kato Katz quantitative method.[8]

Random samples of schistosomiasis-positive school children and schistosomiasis-negative schoolchildren were generated with EpiInfo software (Centers for Disease Control and Prevention, Atlanta, GA). The sample of schistosomiasis-negative school children was three times larger and used as a control. The statistical power of this sample of schistosomiasis-positive and schistosomiasis-negative school children was 82.8% with an odds ratio (OR) of 2.0 and a 95% confidence interval (CI).[9] Residences were visited and entire families were enrolled into the project. Participants provided stool samples for parasitologic examination after the head of the household signed a consent form. The study was reviewed and approved by the Ethical Review Board of the Centro de Pesquisa René Rachou/FIOCRUZ (No. 004/2000).

Household survey. A questionnaire, which included information on monthly income and type of sanitary installations in the household, was provided to each residence. The purpose of this questionnaire was to determine if a relationship existed between specific parameters and schistosomiasis-positive individuals. The complete methodology and results of this survey are described elsewhere.[10]

Data analysis. The chi-square test was used to compare proportions and the Student's t-test was used to compare geometric mean egg count per gram of feces. The parasitologic survey carried out in the schools that identified risk areas for schistosomiasis was evaluated by calculating the sensitivity (probability of finding at least one positive child in a residence where at least one family member was positive), specificity (probability of finding one negative child in a residence where all members were negative), positive predictive value (probability of finding at least one positive family member when there was one positive child in the residence), and negative predictive value (probability of finding a negative family member when there was no positive child in the residence). For these calculations, the residence was chosen as a unit, and we investigated the presence of schistosomiasis-positive family members. The positive and negative school children previously examined were excluded from this analysis. The OR and 95% CI were used to determine the strength of association of results of the parasitologic survey between the school children and their family members. This analysis was conducted using Stata 7 software (Stata Corporation, College Station, TX).

Treatment. All school children and family members positive for any helminthic disease were enrolled into the local health system for treatment. Patients identified as positive for schistosomiasis were treated with praziquantel (adults, 50 mg/kg in a single dose; children ≤ 15 years old, 60 mg/kg in a single dose) or oxamniquine (adults, 15 mg/kg in a single dose; children ≤ 15 years old, 20 mg/kg in a single dose) based on medical findings. Albendazole (adults and children, 400 mg in a single dose) was administered for treatment of all other helminthic diseases.

RESULTS

Stool examinations of 1,533 school children, of whom 1,186 (77.0%) participated in the parasitologic survey, showed that 101 (8.6%) were positive for schistosomiasis. Of the 101 children, 3 moved out of the area and 1 dropped out of the study. The remaining 97 positive school children were included in this investigation. Among the helminthic diseases investigated, schistosomiasis had the highest prevalence (8.6%) with a geometric mean egg count of 50.67 per gram of feces. For other parasites, low prevalences were found: 4.2% for *Ascaris lumbricoides*, 1.8% for *Trichuris trichiura*, 2.1% for hookworm, 2.6% for *Enterobius vermicularis*, and 0.1% for *Hymenolepis nana*.

A total of 270 residences were visited, of which 64 had positive school children and 206 had no positive school children. The mean (SD) number of family members per residence was 5.1 (1.8) in those in which positive school children were found and 5.2 (1.9) ($P = 0.646$) in those in which negative school children were found. Ninety-seven positive school children were found in the 64 residences. These positive school children showed the following distribution among residences: 1 positive in each of 40 residences, 2 positive in each of 16 residences, 3 positive in each of 7 residences, and 4 positive in 1 residence. The remaining 297 negative school children lived in the 206 residences.

Table 1 shows the prevalence and geometric mean egg count per gram for *S. mansoni* among school children and their family members and among family members excluding the school children. A total of 1,304 (92.1%) of 1,415 individuals were examined. Of these, 317 lived in residences with positive school children and 987 lived in residences with negative school children. The prevalence of schistosomiasis was 41.3% among family members of positive school children (including the positive school children), who had a geometric mean egg count of 62.37 per gram of feces and 2.6% among family members of negative school children, who had a geometric mean egg count of 27.48 per gram of feces. This indicated a 2.2-fold greater geometric mean egg count among the family members of positive school children. A possible explanation for this difference in egg burden may be more frequent water contact of the family members and school children in the group with schistosomiasis-positive school children (96.9%) compared with those in the group with schistosomiasis negative schoolchildren (78.4%) ($P < 0.001$, by chi-square test). Detailed data for the water contact pattern has been reported elsewhere.[10]

Two hundred twenty (91.7%) family members of positive school children and 690 (88.3%) family members of negative

TABLE 1

Prevalence and geometric mean egg count per gram for *Schistosoma mansoni* among school children and their family members and among family members (excluding the school children of the sample) in Jaboticatubas, Minas Gerais, Brazil, 2001

Variables	Examined school children and their family members		Examined family members (excluding the 394 school children of the sample)	
	Positive	Negative	Positive	Negative
Registered	337	1,078	240	781
Examined (%)	317 (94.1)	987 (91.6)	220 (91.7)	690 (88.3)
Positive (%)*	131 (41.3)	26 (2.6)	34 (15.5)	26 (3.8)
Negative (%)	186 (58.7)	961 (97.4)	186 (84.5)	664 (96.2)
Geometric mean eggs/gram†	62.37	27.48	65.92	27.48

* $P < 0.001$ (by chi-square test) comparing the prevalence of schistosomiasis between family members of positive and negative school children.
† $P < 0.001$ (by Student t-test) comparing the geometric mean egg/gram between the family members of positive and negative school children.

school children provided stool samples for examination. The mean prevalence of schistosomiasis was 15.5% in 34 positive individuals among 220 family members of positive schoolchildren, who had a geometric mean egg count of 65.92 per gram of feces and 3.8% in 26 positive individuals among 690 family members of negative schoolchildren, who had a geometric mean egg count of 27.48 per gram of feces. The 34 positive individuals were found in 25 residences. Their distribution was 1 positive individual in each of 18 residences, 2 positive in each of 6 residences, and 4 positive in 1 residence. The 26 positive family members of schistosomiasis-negative school children lived in 25 residences. Their distribution was 1 positive in each of 24 residences and 2 positive in 1 residence.

The prevalence of schistosomiasis among family members of both groups is shown in Figure 1. In all age groups, the prevalence of schistosomiasis was significantly higher ($P < 0.01$, by chi-square test) among family members of positive school children. In those less than 15 years old, 4 cases of schistosomiasis were diagnosed: 3 in residences of positive school children and 1 in a residence of a negative child. Among the four positive children, two were 12 years old and not enrolled in school.

The association between the infections among school children and their family members is shown in Table 2. The presence of one positive pupil in the residence increased the chances by 4.56 in finding at least one other positive family member. Fifty (18.8%) of 226 residences had at least one other positive family member besides the pupil. Twenty-five (12.3%) of 203 residences of negative school children had a positive family member. Another positive family member was found in 25 (39.7%) of 63 residences of positive school children.

The estimates for sensitivity (50.0%), specificity (82.0%), positive predictive value (PPV) (39.1%), and the negative predictive value (87.7%) are shown in Table 3. No differences were found in these values relative to family income. The lack of sanitary installations resulted in an increase in these values compared with those that had internal or external sanitary installations.

DISCUSSION

The identification of individuals infected with *S. mansoni* living in areas of low prevalence is difficult because the number of egg-positive persons is relatively small in relation to the
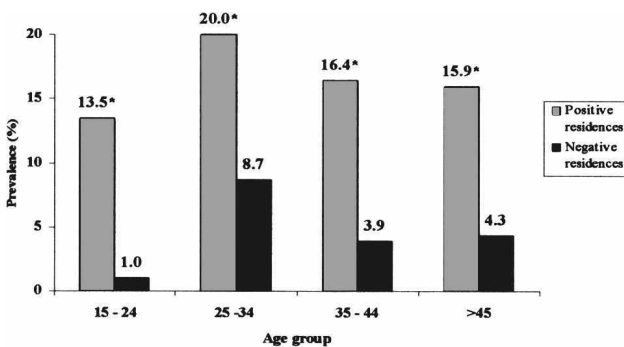

FIGURE 1. Prevalence of schistosomiasis among residences of positive and negative school children. *$P < 0.01$, by chi-square test.

TABLE 2
Association between the infections among school children and their family members in Jaboticatubas, Minas Gerais, Brazil, 2001*

Residences with school children	Residences with a family member (excluding school children)			
	Positive (%)	Negative (%)	Total	OR (95% CI)
Negative	25 (12.3)	178 (87.7)	203	1.0
Positive	25 (39.7)	38 (60.3)	63	4.56 (2.37 – 8.77)
Total	50 (18.8)	216 (81.2)	266	–

* OR = odds ratio; CI = confidence interval.

total population and low morbidity is shown by carriers of this disease. To overcome these difficulties, new strategies for detecting this infected and often asymptomatic group of the population must be developed. The importance of peridomiciliary schistosomiasis transmission relative to leisure and household activities, together with water use, is well known.[6,7] Such activities may be related to infection foci, leading to a higher risk of the transmission of the disease within the family members.

Based on these findings and the recommendation of Montresor and others[4] to use school children between 7 and 14 years of age as indicators of control strategies in helminth-endemic areas, we attempted to combine both approaches to identify positive individuals within a community in a low transmission area. In this study, the results of the stool examinations of schoolchildren are typical for an area with a low prevalence of schistosomiasis, showing a prevalence of 8.6%. However, the prevalence in residences of infected schoolchildren was 41.3%, which was 15.89 times higher than the prevalence of 2.6% in residences of uninfected school children. When school children in both groups were excluded, the prevalence in family members was only four times higher, with values of 15.5% in those related to schistosomiais-positive school children and 3.8% in those related to schistosomiasis-negative school children. Our data show that treatment of school children may miss a significant number of infected asymptomatic adults living in the same residence, who are easily accessible and probably responsible for the maintenance of the parasitic cycle in the area.

Since our objective was identification of positive individuals in a community using school children as indicators, it may be expected that the parasitologic survey would show an increased sensitivity and positive predictive value. The sensitivity of identifying a positive schoolchild in a residence in which another positive person was found was 50.0%. The positive predictive value of identifying at least one positive family member in a residence in which a positive school child lived was 39.1%. Higher values in this context have been observed,[11] which showed that the prevalence observed in schools could predict the prevalence in the community and therefore indicate target areas for control programs. In contrast to the study of Rodrigues and others,[11] the current study focused on the identification of residences with a higher frequency of individuals positive for schistosomiasis, and not only on identification of areas of increased prevalence. We observed a lower sensitivity and positive predictive value in our study. Nevertheless, in only 12.3% (negative predictive value = 100%) of residences of negative schoolchildren was a positive family member found, which indicates that application of our methodology results in only a small loss of positive individuals within the community. This low proportion of

Table 3

Sensitivity, specificity, and predictive values of the parasitologic survey among school children in relation to the results of stool examinations of their family members in Jaboticatubas, Minas Gerais, Brazil, 2001*

Variable	Sensitivity	Specificity	PPV (95% CI)	NPV (95% CI)
Global	50.0	82.0	39.1 (27.4–52.1)	87.7 (82.2–91.7)
Income per family				
≤ 0.40 MW† (n = 818)	48.3	82.9	42.4 (26.0–60.6)	86.0 (77.6–91.7)
> 0.40 MW† (n = 522)	47.4	87.1	42.9 (22.6–65.6)	89.0 (80.3–99.3)
Sanitary installation				
None (n = 268)	70.0	85.7	58.3 (28.6–83.5)	90.9 (74.5–97.6)
External (n = 130)	50.0	63.2	22.2 (3.9–59.8)	85.7 (56.2–97.5)
Internal (n = 1,017)	44.4	83.4	37.2 (23.4–53.3)	87.2 (80.7–91.8)

* PPV = positive predictive value; NPV = negative predictive value; CI = confidence interval; MW = minimum wage.
† MW = 260 Reais (approximately $90US).

missing positive individuals is associated with an increased prevalence observed in positive schoolchildren (15.9 times higher), as well as an increased association between stool samples of school children and their family members (OR = 4.6), which indicates the potential of using school children as indicators for infection with *S. mansoni* among their family members.

Our methodology was limited because we excluded residences with no children between 7 and 14 years of age. In addition, elderly, single people, couples without children, and couples with small children were not included. The effect of these groups on disease prevalence will depend on their demographic distribution in the community. In rural areas with a more traditional life style, where elderly live with their families, young couples live with their parents, and there are few single people and couples with no children, the impact will be smaller than in a modern metropolitan community, with a high percentage of single people, couples without children, and elderly living in a different residence from their children and grandchildren. Another limitation of this approach was the low sensitivity. However, it is not clear whether these results will be observed in other areas. Therefore further applications of this methodology in different sociocultural settings are necessary to verify the consistency of these results.

If the data from this study is confirmed by other investigations, a considerable economic impact on schistosomiasis control programs in areas of low prevalence may be expected. The definition of specific targeted groups for stool examination, which in this case is school children and the residences of positive school children, will decrease the number of unnecessary negative diagnostic examinations. Economically, this decrease in the number of stool examinations means a significant reduction in personnel and material costs in detecting the same proportion of schistosomiasis-positive individuals.

The data of this study also suggests that family members of infected school children play an important role in maintaining the transmission of the disease in the peridomiciliar environment. If one considers that among family members habits of water contact are similar, a higher risk of infection and re-infection exists. Under these circumstances, it is necessary to re-define current criteria to detect these adult family members and provide adequate treatment. The active search for these positive family members is often hampered by lack of resources, i.e., time and personnel. In this case, health education in the school proved to be a valid alternative to reach family members. After a comprehensive education campaign, these school children will have a conscious knowledge about prevention, transmission, and general health risks of the disease. Mobilized in this way, school children have proven to be multipliers in transmitting this awareness to other family members, especially adults, and therefore facilitating diagnosis and treatment among their family members.[12]

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REFERENCES

1. Engels D, Chitsulo L, Montresor A, Savioli L, 2002. The global epidemiological situation of schistosomiasis and new approaches to control and research. *Acta Trop 82:* 139–146.

2. Lambertucci JR, Serufo JC, Gerspacher-Lara R, Rayes AAM, Teixeira R, Nobre V, Antunes CMF, 2000. *Schistosoma mansoni*: assessment of morbidity before and after control. *Acta Trop 77:* 101–109.

3. Katz N, 1998. Schistosomiasis control in Brazil. *Mem Inst Oswaldo Cruz 93 (Suppl 1):* 33–35.

4. Montresor A, Crompton DWT, Gyorkos TW, Savioli L, 2002. *Helminth Control in School-Age Children: A Guide for Managers for Control Programmes.* Geneva: World Health Organization.

5. Guyatt HL, Brooker S, Donnelly CA, 1999. Can prevalence of infection in school-age children be used as an index for assessing community prevalence? *Parasitology 118:* 257–268.

6. Cairncross S, Blumenthal U, Kolsky P, Maores L, Tayeh A, 1996. The public and domestic domains in the transmission of disease. *Trop Med Int Health 1:* 27–34.

7. Watts S, Khallaayoune K, Bensefia R, Laamrani H, Gryseels B,

1998. The study of human behaviour and schistosomiasis transmission in an irrigated area in Moroco. *Soc Sci Med 46:* 755–765.

8. Katz N, Chaves A, Pellegrino J, 1972. A simple device for quantitative stool thick-smear technique schistosomiasis mansoni. *Rev Inst Med Trop Sao Paulo 14:* 397–400.

9. Dean AG, Dean JA, Burton AH, Dicker RC, 1990. *EPI-INFO, Version 6.04: A Word Processing Database and Statistics Program for Epidemiology on Microcomputers.* Atlanta, GA: Centers for Disease Control and Prevention.

10. Massara CL, Peixoto SV, Barros HS, Enk MJ, Carvalho OS, Schall VT, 2004. Factors associated with schistosomiasis mansoni in a population from the municipality of Jaboticatubas, State of Minas Gerais, Brazil. *Mem Inst Oswaldo Cruz 99 (Suppl 1):* 127–134.

11. Rodrigues LC, Wheeler JG, Shier R, Guerra HL, Pimenta F Jr, Lima e Costa MF, 2000. Predicting the community prevalence of schistosomiasis mansoni from the prevalence among 7- to 14-year-olds. *Parasitology 121:* 507–512.

12. Massara CL, 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.