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A Combined Strategy to Improve the Control of *Schistosoma mansoni* in Areas of Low Prevalence in Brazil

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Abstract. Results of stool examinations for infections with *Schistosoma mansoni* among schoolchildren, living in a village of Minas Gerais State, Brazil, were used as an indicator to identify schistosomiasis-positive individuals within the entire population. This new approach is based on dividing the community into schoolchildren, members of households of schistosomiasis-positive and -negative schoolchildren, and members of households without schoolchildren. Each subgroup was evaluated comparing different sampling efforts with the predetermined "gold standard" to find the best relationship between detection rate and sampling effort. Consequently these results were combined, and a proposal for a new strategy, valid for an entire community, was elaborated. This alternative approach during the screening process permits to treat a similar proportion of positives as detected with 6 Kato–Katz slides of 3 stool samples, with 3-fold reduced sampling effort, enhancing the efficiency of schistosomiasis control programs in low-endemic areas.

INTRODUCTION

In Brazil, due to decades of successful application of control programs, the number of low-endemic areas increased significantly. Although morbidity and mortality of infections with *Schistosoma mansoni* were reduced progressively during this period, transmission continues nearly unchanged.[1] This is confirmed by an increase of the geographical extension of the disease, the appearance of new foci and local outbreaks of acute schistosomiasis, especially in areas of rural tourism, which also indicates that surveillance and control of schistosomiasis in endemic areas with low prevalence remain problematic.[2–4] Besides other factors, such as migration and insufficient sanitation infrastructure, lack of success seems also to be based on the diagnostic screening approach at the population level. The nationwide strategy currently applied—i.e., 1 Kato–Katz (KK) slide of a single stool sample—to determine infection rate, does not provide the necessary sensitivity and accuracy. Consequently, figures for prevalence in low-endemic areas are underestimated and not reliable.[5] Studies carried out to develop more efficient diagnostic alternatives for the sustainable evaluation of prevalence and permanent epidemiologic surveillance did not result in a satisfactory solution for this problem. These alternative diagnostic tools are not cost-effective, do not show sufficient sensitivity, or are not easy to use under field conditions and at large scale.[6] This study intends—in contrast to the research, which tries to develop new diagnostic tools—to improve the efficacy of the current diagnostic methodology, namely, the KK technique, by combining it with an approach based on an alternative screening strategy and epidemiologic data common in areas of low prevalence. The recently described approach to use results of stool examinations of schoolchildren as indicator for schistosomiasis-positive individuals in a community seems to be a promising methodology in this context.[7] The current study tries to validate this methodology in a different setting and, beyond that, to develop a proposal of an improved strategy for the control and surveillance of schistosomiasis in low-endemic areas.

MATERIALS AND METHODS

Study area. Chonim de Cima, a small town in the county of Governador Valadares, is located in the northeast of Minas Gerais state, Brazil. This location was selected because it is situated in an area of low prevalence for schistosomiasis and it offers the following favorable conditions: the population has never received treatment through the national schistosomiasis control program, the population size of 1,448 inhabitants was adequate for the study purpose, and school enrollment rate was > 90.0%, representing the Brazilian average. The study was carried out between 2005 and 2006.

The local economy is based on agriculture, cattle breeding, and small-scale regional trade. The area is characterized by multiple water sources, like brooks and small lakes, which are used for professional and leisure activities of the local population. The main brook of the area crosses the town and serves as principal recipient for untreated sewage.

Study population. In cooperation with the local health authorities (PSF, Family Health Program), all residents (1,448) and their households (404) were registered. Nonpermanent residents (183) were excluded from this study, resulting in a total number of 1,265 participants. All 369 pupils > 6 years of age, attending the only school, located in the center of the town, participated in this project.

A subset of the population, denominated as the experimental group and representative for the general population, was selected to limit the enormous quantity of stool samples and stool examinations during the in-depth analysis of the infection rate for schistosomiasis. The sample size was calculated based on a test on comparison of proportions with a confidence level of 95.0% and a test power of 90.0%. The prevalence of 13.0% among schoolchildren, detected by a pilot study among 100 pupils, and an expected prevalence of 22.0% for the population with a size of 1,265 individuals were used to calculate the minimum sample size of 289 individuals. The selection process, designed as a systematic random sampling procedure, resulted in an experimental group consisting of 305 individuals living in 111 houses.

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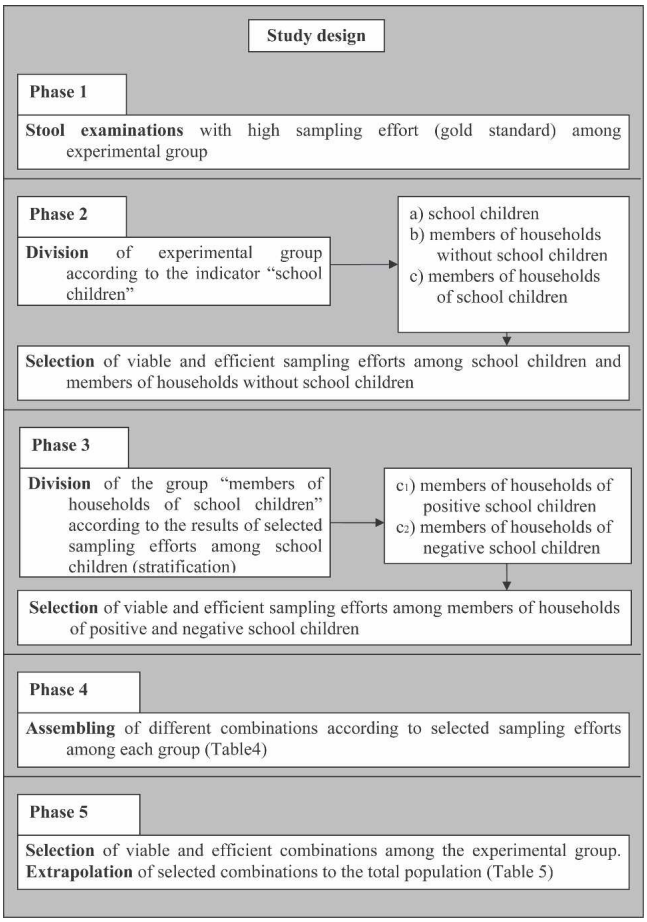

DIAGRAM 1. Study design for the development of the improved strategy in detecting *S. mansoni* positives among the experimental group.

Parasitological survey. After explaining the purpose of the project, the total population of 1,265 participants was screened for schistosomiasis by examining 2 slides of a single stool sample according to the KK technique.[8]

The stool samples for the experimental group consisting of 305 participants, collected during a 2-week period, were examined in the following manner: 6 slides of the first and 2 slides of the second and the third stool specimens, resulting in a total number of 10 slides for 3 stool specimens. A number of the 264 individuals of the experimental group returned a fourth stool sample, 66 of which provided enough material for 6 smears, 1 for 5 slides, 196 for 2 slides, and 1 for 1 slide. Furthermore, 0.5 g of each of 452 stool samples of the experimental group was processed by the formol–ether centrifugation technique according to Blagg and others,[9] and the total sediment was examined. The sum of the results of all stool examinations of all samples of both techniques among the 305 participants served to establish the reference value of prevalence, which was called the "gold standard."

Technicians of the Laboratory of Schistosomiasis in the Rene Rachou Research Center/Fiocruz and the Secretary of Health for the State of Minas Gerais read all slides, and to ensure diagnostic efficacy, 10% of all slides were re-examined.

Study design. In the first step, the approach to use schoolchildren as the indicator for schistosomiasis as described by Massara and others[7] was reproduced in this study among the household members of the total population, to confirm its validity in another setting. In the second step, this methodology was combined with the results of increased sampling efforts, thus enabling development of a new strategy, which extends to an entire population and not only to the members of households of schoolchildren. For this purpose, the population of the experimental group was divided in 4 groups. The first consisted of all schoolchildren, the second of all participants without schoolchildren in their households. The third and fourth groups were stratified according to stool examination results of different sampling efforts among the schoolchildren, one group of members of households of schistosomiasis-positive schoolchildren and the other group of members of households of schistosomiasis-negative schoolchildren. Retrospectively, different combinations were designed by evaluating the different sampling efforts of each subgroup of the experimental group to identify and treat as many as possible schistosomiasis-positive individuals by using a minimum number of stool samples and slides, compared with the "gold standard" (Diagram 1).

Data analysis. The χ^2 test was used to compare proportions between groups. The odds ratio was used to determine the strength of association of results of stool examinations between groups of the population. The proportion of correctly detected individuals positive and negative for schistosomiasis of different sampling efforts in relation to the gold standard is denominated "efficacy" and expressed in percent (Tables 1 and 5). All tests were carried out with a 95.0% level of confidence. The software package MINITAB 14.0 was used to carry out these calculations.

Treatment. All participants positive for schistosomiasis were treated with praziquantel according to the recommendation of the Brazilian Ministry of Health (adults, 50 mg/kg in a single dose, children $\leq$ 15 years old, 60 mg/kg in a single dose). Those positive for soil-transmitted helminthiasis (STH) (were treated with albendazole, both adults and chil-

TABLE 1

Results in absolute numbers and percentage of schistosomiasis-positive and -negative individuals according to the increasing numbers of slides and stool samples in the experimental group*

Experimental group (N = 305)							
Sampling effort		Result			Comparison with "gold standard" (%)		
Slides	Samples	Neg.	Pos.	Prev. (%)	Sensitivity	NPV	Efficacy†
1	1	263	42	13.8	38.9	74.9	78.4
2	1	258	47	15.4	43.5	76.4	80.0
3	1	252	53	17.4	49.1	78.2	82.0
4	1	251	54	17.7	50.0	78.5	82.3
5	1	248	57	18.7	52.8	79.4	83.3
6	1	247	58	19.0	53.7	79.8	83.6
2	2	242	63	20.7	58.3	81.4	85.2
4	2	237	68	22.3	63.0	83.1	86.9
3	3	234	71	23.3	65.7	84.2	87.9
6	3	226	79	25.9	73.1	87.2	90.5
10‡	3	222	83	27.2	76.9	88.7	91.8
"Gold standard"§		197	108	35.4	100.0	100.0	100.0

* Neg., schistosomiasis negative; Pos., schistosomiasis positive; Prev., Prevalence in %; NPV, negative predictive value.

† Efficacy refers to the proportion of true positives and true negatives detected by a specific sampling effort in relation to all positive and negative cases detected by the gold standard.

‡ Six slides of the first sample and 2 slides each of the second and third samples.

§ "Gold standard" refers to the reference value of prevalence consisting of the sum of all Kato–Katz slides of all stool samples and of all stool examinations processed according to the formol–ether centrifugation technique.

TABLE 2

Number and percentage of schistosomiasis positives and negatives detected in households of positive and negative schoolchildren found by Massara and others and our in study among the total population, using the same sampling effort of 2 slides of a single sample

Household members	Households with positive schoolchildren		Households with negative schoolchildren	
	Massara and others	Our data	Massara and others	Our data
Positives	25 (39.7)	16 (43.2)	25 (12.3)	30 (20.4)
Negatives	38 (60.3)	21 (56.8)	178 (87.7)	117 (79.6)
Total	63 (100.0)	37 (100.0)	203 (100.0)	147 (100.0)

dren, 400 mg in a single dose) at the local health-care facility.[10]

Ethical considerations. All participants were informed about the purpose of this study, the possible risks, and inconveniences. The study protocol was received and approved by the Ethical Review Board of the Réne Rachou Research Center/Fiocruz (No. 04/2005).

RESULTS

Parasitological survey. According to the increase of the number of slides per stool sample and the number of stool samples, this study shows a steady increase of schistosomiasis-positive individuals among the total population and the experimental group. The prevalence in the total population ranges between 11.2% with 1 slide and 12.5% with 2 slides from the same sample, up to 20.8% considering all stool samples, including those of the in-depth analysis in the experimental group. In this study, a total of 263 schistosomiasis-positive individuals were identified among the 1,265 participants. Among the 305 participants of the experimental group, 42 individuals, corresponding to a prevalence of 13.7%, proved positive for schistosomiasis; by applying the same methodology as for the entire population, 47 individuals were identified, resulting in a prevalence of 15.4%. The experimental group was representative for the total population in relation to age (χ^2 test; $P = 0.147$) and gender (χ^2 test; $P = 0.137$). Furthermore, no statistically significant difference was found between the total population and the experimental group for the distribution of schistosomiasis-positive and -negative individuals, with data obtained through the examination of 2 slides of 2 stool samples according to the KK technique (χ^2 test; $P = 0.174$). The detailed increase of prevalence according to the increased number of slides and stool samples of the in-depth analysis among the experimental group is shown in Table 1. Our data for prevalence in the experimental group show that screening the population with 1 KK slide, which is the current approach recommended by the Brazilian Ministry of Health, misses 66 of the 108 positives (61.1%) compared with the numbers according to our "gold standard." Extrapolating these figures to the total population reveals totals of 448 (confidence interval, CI = 380–516) positive individuals and consequently 274 (CI = 249–298) undetected, and also untreated carriers of schistosomiasis, who maintain transmission of the disease in the area. The data also indicate that the sensitivity of such a strategy—KK examination of only 1 slide per stool sample—is only 38.9% with an efficacy of 78.4%.

TABLE 3

Comparison of odds ratios found by Massara and others and our in study among the total population, using the same sampling effort of 2 slides of a single sample

Comparison	Massara and others	Our data
Odds ratio	4.56	2.97
95% Confidence interval	2.37–8.77	1.38–6.38

Validation of the approach of using schoolchildren as indicators in another setting. The results obtained by Massara and others could be confirmed by our data (Tables 2 and 3). There was no statistically significant difference in the proportion of the schistosomiasis-positive and -negative household members among the households of positive schoolchildren (χ^2 test; $P = 0.727$ for the comparison with the total population, and P value = 0.079 for comparison with the experimental group). Although there was a statistically significant difference in the proportion among households with negative schoolchildren (χ^2 test; P value = 0.040), evaluation of the

TABLE 4

Variability in the number of positives depending on the increase in the number of Kato–Katz slides and samples among 4 groups of the experimental population; results are shown in absolute numbers of positive individuals and in percentage of prevalence for each of the 4 groups

Sampling effort		Results for increasing sampling effort according to stratification							
		Schoolchildren ($N = 121$)		Members of households without schoolchildren ($N = 70$)		Members of households of positive schoolchildren ($N = 23$)		Members of households of negative schoolchildren ($N = 91$)	
Slides	Samples	Positives	Prevalence (%)	Positives	Prevalence (%)	Positives	Prevalence (%)	Positives	Prevalence (%)
1	1	18	14.9	8	11.4	4	17.4	12	13.2
2	1	20	16.5	9	12.9	5	21.7	13	14.3
3	1	21	17.4	10	14.3	7	30.4	15	16.5
4	1	22	18.2	10	14.3	7	30.4	15	16.5
5	1	23	19.0	10	14.3	9	39.1	15	16.5
6	1	23	19.0	11	15.7	9	39.1	15	16.5
2	2	21	17.4	15	21.4	9	39.1	18	19.8
4	2	23	19.0	17	24.3	10	43.5	18	19.8
3	3	25	20.7	15	21.4	10	43.5	21	23.1
6	3	28	23.1	19	27.1	11	47.8	21	23.1
10*	3	29	24.0	20	28.6	12	52.2	22	24.2
"Gold standard"†		41	33.9	25	35.7	13	56.5	29	31.9

* Six slides of the first sample and 2 slides each of the second and third samples.
† "Gold standard" refers to the reference value of prevalence consisting of the sum of all Kato–Katz slides of all stool samples and of all stool examinations processed according to the formol–ether centrifugation technique.

TABLE 5
Comparison of different combinations composed of varying sampling efforts among the four groups of the experimental group

Combinations of strategies	Sampling effort (no. of slides/no. of samples)				Results for experimental group (N = 305)				
		Members of households							
	Schoolchildren	Without/negative schoolchildren	Positive schoolchildren	Total number of slides	Negatives	Positives	Prevalence	Sensitivity*	Efficacy*
Combination 1	**1/1**	**1/1**	**1/1**	**305**	**263**	**42**	**13.8**	**38.9**	**78.4**
Combination 2	1/1	1/1	0/0†	282	254	51	16.7	47.2	81.3
Combination 3	2/1	2/1	2/1	610	258	47	15.4	43.5	80.0
Combination 4	3/1	3/1	3/1	915	252	53	17.4	49.1	82.0
Combination 5	3/3	3/3	3/3	915	234	71	23.3	65.7	87.9
Combination 6	**6/3**	**6/3**	**6/3**	**1830**	**226**	**79**	**25.9**	**73.1**	**90.5**
Combination 7	1/3	1/1	0/0†	518	245	60	19.7	55.6	84.3
Combination 8	**3/3**	**2/2**	**0/0**†	**673**	**232**	**73**	**23.9**	**67.6**	**88.5**
Combination 9	6/3	1/1	0/0†	879	242	63	20.7	58.3	85.2
Combination 10	5/1	1/2	0/0†	923	235	70	23.0	64.8	87.5
Combination 11	3/3	3/3	0/0†	828	230	75	24.6	69.4	89.2
Combination 12	2/2	2/2	2/2	610	242	63	20.7	58.3	85.2
Combination 13	2/2	2/2	0/0†	560	238	67	22.0	62.0	86.6
Combination 14	1/2	1/1	0/0†	401	251	54	17.7	50.0	82.3
Combination 15	6/3	6/3	0/0†	1644	223	82	26.9	75.9	91.5
"Gold standard"	‡	‡	‡	5652	197	108	35.4	100.0	100.0

* Sensitivity (correctly identified positive individuals) and efficacy (correctly identified positive and negative individuals) compared with "gold standard."
† Treatment without prior stool examinations.
‡ "Gold standard" refers to the reference value of prevalence consisting of the sum of all Kato–Katz slides of all stool samples and of all stool examinations processed according to the formol–ether centrifugation technique.

odds ratios (ORs) in both studies shows a large amplitude of the 95.0% CI with a wide overlapping area, indicating significant similarity (our data—OR, 2.971; 95.0% CI = 1.384–6.381; data of Massara and others—OR, 4.684; 95.0% CI = 2.431–9.026).

Evaluation of the approach at population level. Because the experimental group is representative for the total population in age, gender, and distribution of schistosomiasis-positive individuals, this methodology was applied for all individuals of this group. The variability of the number of infected, detected by the KK technique depending on the number of slides per stool sample and number of stool samples, as well as the inclusion of the values for the "gold standard" revealed, as expected, increasing numbers in all 4 groups. These 4 groups are described above in the Material and Methods section "Study Design." Table 4 shows the figures for these groups in detail. Applying stratifications based on results obtained by examination of schoolchildren shows that the number of positives among the members of households of positive and negative schoolchildren increases with increases in the number of KK slides and samples.

On the basis of these data, a separate strategy for each of the 4 groups can be adopted, resulting in different combinations of these strategies. Each combination is characterized by the number of slides examined, as well as by specific values for prevalence, sensitivity, and efficacy. The figures for the different combinations are shown in Table 5. Combinations 8 and 13 increase the number of positives detected from 42 to 73 (73.8%) and from 42 to 69 (59.5%), respectively, with 2.2- and 1.8-fold increases in slides examined in relation to screening the entire population with 1 KK slide. In relation to 3 stool samples examined by 2 KK slides each, among the entire population, combinations 8 and 13 reveal insignificant reductions in the proportions of schistosomiasis-positive individuals of 2.0% and 3.9%, respectively, but considerably reduced sampling efforts (by 2.7- and 3.3-fold), which means 1,157 fewer slides for combination 8 and 1,270 fewer slides for combination 13 among the experimental group. Extrapolation of these figures to the total population means 4,799 fewer slides for combination 8 and 5,267 fewer slides for combination 13 (Table 6). Combinations 8 and 13 reveal themselves as the most effective options, considering the number of positives detected or treated in relation to the number of slides examined. These data are observed in Figure 1. Comparisons

TABLE 6
Results for extrapolation of combinations at the population level, including the total number of Kato–Katz slides examined*

Population		Combination 1†				Combination 8‡				Combination 6§				"Gold standard"¶			
		Neg.	Pos.	Prev.	No. of slides	Neg.	Pos.	Prev.	No. of slides	Neg.	Pos.	Prev.	No. of slides	Neg.	Pos.	Prev.	No. of slides
EG		263	42	13.8	305	232	73	23.9	673	226	79	25.9	1,830	197	108	35.4	5,652
CI 95%	LI	275	30	9.9		247	58	19.1		241	64	21		213	92	30.0	
	LS	251	54	17.6		217	88	28.7		211	94	30.8		181	124	40.8	
TP		1091	174	13.8	1,265	962	303	23.9	2,791	937	328	25.9	7,590	817	448	35.4	23,442
CI 95%	LI	1140	125	9.9		1,023	242	19.1		1,000	265	18.5		885	380	30.0	
	LS	1042	223	17.6		902	363	28.7		875	390	30.8		749	516	40.8	

* EG, experimental group; TP, total population; Neg., schistosomiasis negative; Pos., schistosomiasis positive; Prev., prevalence in %.
† Combination 1: 1 slide/1 stool sample among all participants (recommendation of the Brazilian Ministry of Health).
‡ Combination 8: 3 slides/3 samples among schoolchildren + 2 slides/2 stool sample among household members without schoolchildren and of schistosomiasis-negative schoolchildren + proportion of treated positive household members without prior stool examination of schistosomiasis-positive schoolchildren.
§ Combination 6: 6 slides/3 stool samples among all participants.
¶ "Gold standard" refers to the reference value of prevalence consisting of the sum of all Kato–Katz slides of all stool samples and of all stool examinations processed according to the formol–ether centrifugation technique.

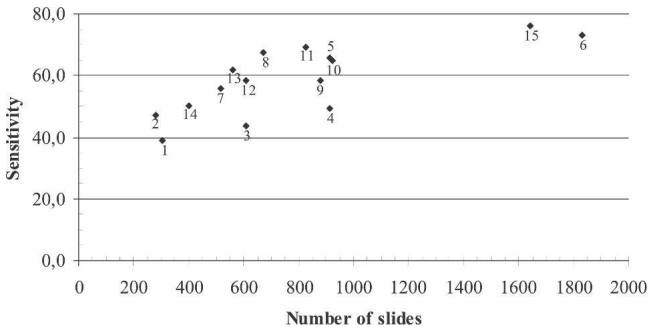

FIGURE 1. Relation between number of slides and sensitivity of each of the 15 combinations (◆ 1 to ◆ 15) composed of varying sampling efforts among the 4 groups of the experimental population.

among the proportions of positives for each of the 2 combinations with the approach using 1 KK slide for the entire population (prevalence of 13.8%) show that there is significant difference in the proportion of positives detected (combination 8—prevalence of 23.9%, χ^2 test; $P = 0.001$; combination 13—prevalence of 22.0%, χ^2 test; $P = 0.008$). On the other hand, there is no statistically significant difference when both combinations are compared with the proportion of positives found by examining 3 stool samples with 2 KK slides each (proportion of positives, 25.9%: χ^2 test, combination 8, $P = 0.574$; combination 13, $P = 0.255$). Because the experimental group is representative for the total population, data for the combinations among the experimental group may be extrapolated to the total population. A selected set of these extrapolations are outlined in Table 6. In our setting, among the total population, this increased sampling effort (3 stool samples + two KK slides each) reveals a total number of 328 (CI = 265–390) positives detected and 120 (CI = 98–142) or 26.8% missed, indicating a significant improvement of the detection rate (χ^2 test; $P = 0.000$) and of sensitivity and efficacy with values of 73.1% (CI = 68.1–78.1) and 90.5% (CI = 87.2–93.8), respectively.

DISCUSSION

Our study supports the conclusions drawn by Massara and others, that there is an association between the infection rates of schistosomiasis among schoolchildren and their household members. Schistosomiasis-positive schoolchildren indicate, according to Massara and others, a 4 times—and according to our data—a 3 times higher probability to detect another positive individual living in the same household, compared with members of households of schistosomiasis-negative schoolchildren. The difference found in the direct comparison of the proportions of positive individuals among households of negative schoolchildren (χ^2 test; P value = 0.040) is probably caused by the fact that Massara and others used a sample of households of schistosomiasis-negative schoolchildren 3 times as large as that of positive schoolchildren and not the entire population, as in our study, resulting in an underestimation of positive household members among the households of negative schoolchildren.

Our approach was then applied to the entire population, by using schistosomiasis-positive and -negative schoolchildren as indicators. This approach of categorizing an entire population resulted in division of this population into 4 distinctive groups with specific infection rates for each. In combination with in-depth analysis of the infection rate of each of the 4 groups, a new strategy was developed, which shows potential to improve the efficiency of the control of schistosomiasis in low-endemic areas.

An important point regarding schistosomiasis control in low-endemic areas is the fact that prevalence is severely underestimated.[5] This is based on a lack of sensitivity of the diagnostic method and consequently causes a negative impact on the efficiency of control programs.[11] Traditionally, to increase the sensitivity of the diagnostic method, it is recommended that the number of stool samples and KK slides examined per specimen be increased. There exists a general agreement that 3 stool samples examined by 2 KK slides each ensure solid and reliable figures for infection rates.[12–14] Unfortunately, this approach is not sustainable because the increased sampling effort is not practicable at large scale under field conditions and the 6-fold increase of KK slides—in our study population, from 1,265 to 7,590 slides—results in an unaffordable increase in expenditures for mass screening. One solution to this dilemma is blanket mass treatment without prior screening, as suggested decades ago.[15,16] The main problem regarding this option is the high number of unnecessary treatments, which in our setting results in 817 individuals, or 64.6% of the population. Although praziquantel is a relatively safe drug, causing few side effects, ethical considerations have to be taken into account if mass treatment under such circumstances is appropriate.

The other option, if improvement of schistosomiasis-control programs in low-endemic areas is the goal, lies in the combination of the diagnostic technique with an indirect approach which indicates the most-infected segments of the population. As mentioned above, screening of schoolchildren and using their stool examination results as indicators for identifying schistosomiasis-positive individuals among their household members, can provide this valuable information. In our setting, according to figures for the "gold standard" and including the schoolchildren into the households, rates of infection are 61.5% for households of positive schoolchildren, 14.5% for households of negative schoolchildren, and 35.7% for households without schoolchildren among the experimental group. These figures clearly show how the sampling effort should be directed to increase the efficacy of the screening method. Using the same figures, but excluding the schoolchildren, infection rates are observed to be 56.5% for households of positive schoolchildren and 31.9% for households of negative schoolchildren (Table 4). The finding that 1 segment of the population, namely, the household members of schistosomiasis-positive schoolchildren, revealed, according to the in-depth analysis, an infection rate > 50.0%, which constitutes another important pillar of this new strategy. Given this high infection rate, targeted mass treatment without prior screening is justified.[10,17] Mass treatment of this segment also helps to limit the considerable number of stool examinations, resources for which can be used for other segments of the population to increase the detection rate.

Putting this model into practice means, first, to screen all schoolchildren with a relatively high sampling effort and to treat all those identified as positive for schistosomiasis together with all their household members. Next, all members of households without schoolchildren and those of schistosomiasis-negative schoolchildren are screened and treated as

well. According to different sampling efforts, various combinations of the screening procedures can be designed (Table 5). Of these combinations, numbers 8 and 13 prove to be the most effective, considering the numbers of slides examined and the numbers of positives reached for treatment. Regarding the sampling effort, it is worth mentioning that both combinations require examination of more slides than the current approach (1 KK slide per person). The number of slides examined increases from 305 for 1 KK slide for all participants to 673 for combination 8 and to 560 for combination 13 among the experimental group, and from 1,256 for 1 KK slide for all participants to 2,791 for combination 8 and to 2,323 for combination 13 among the total population. Nevertheless, the increase in number of slides for combinations 8 and 13 is reasonable in comparison to 1,830 slides for 3 stool samples examined by 2 KK slides among the experimental group and 7,590 slides among the total population, which would be needed to reach the same detection rate as obtained by our method's fewer slides.

Our data indicate that there is room for improvement of control strategies, even if the least sensible diagnostic procedure, KK examination of a single stool sample with one slide, is used selectively by combining it with a supportive approach, which would still provide information to direct the sampling effort. Furthermore, as this above-described new strategy focuses on schoolchildren for identification of schistosomiasis-positive individuals within a community, there is an opportunity to combine such a program with health-educational activities at the school and community levels, which also enhance the success of such a program through better adherence and compliance.[18–20] School- and community-based control programs are known to provide mechanisms not only to engage the population but also make programs sustainable and maintainable by active participation of the community. Integration with other control programs, such as for STH, filariasis, and others, makes it possible to combine such programs, which consequently results in reduced costs for integrated programs.[21,22]

However, there are limitations to the suggested strategy, which are not only based on the specific conditions of our setting, but also on the requirement of a developed primary health-care structure, high school enrollment, and a solid family structure within the community, which shows similar water-contact patterns among household members. Most of these requirements are met for rural or semi-urban areas, especially in Brazil, and it was the case for our study area. Therefore, our findings may serve as a proposal for the improvement of schistosomiasis control in areas of low transmission.

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