Rapid screening for *Schistosoma mansoni* in western Côte d'Ivoire using a simple school questionnaire

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The distribution of schistosomiasis is focal, so if the resources available for control are to be used most effectively, they need to be directed towards the individuals and/or communities at highest risk of morbidity from schistosomiasis. Rapid and inexpensive ways of doing this are needed, such as simple school questionnaires. The present study used such questionnaires in an area of western Côte d'Ivoire where *Schistosoma mansoni* is endemic; correctly completed questionnaires were returned from 121 out of 134 schools (90.3%), with 12 227 children interviewed individually. The presence of *S. mansoni* was verified by microscopic examination in 60 randomly selected schools, where 5047 schoolchildren provided two consecutive stool samples for Kato–Katz thick smears. For all samples it was found that 54.4% of individuals were infected with *S. mansoni*. Moreover, individuals infected with *S. mansoni* reported ''bloody diarrhoea'', ''blood in stools'' and ''schistosomiasis'' significantly more often than uninfected children. At the school level, Spearman rank correlation analysis showed that the prevalence of *S. mansoni* significantly correlated with the prevalence of reported bloody diarrhoea ($P = 0.002$), reported blood in stools ($P = 0.014$) and reported schistosomiasis ($P = 0.011$). Reported bloody diarrhoea and reported blood in stools had the best diagnostic performance (sensitivity: 88.2%, specificity: 57.7%, positive predictive value: 73.2%, negative predictive value: 78.9%). The study, which is probably the largest of its kind ever undertaken in Africa, revealed a moderate diagnostic performance of questionnaires for identifying individuals and/or communities at high risk from *S. mansoni*.

Keywords: Côte d'Ivoire; diagnostic techniques and procedures; epidemiological studies; questionnaires, utilization; *Schistosoma mansoni*, diagnosis; schools.

Voir page 396 le résumé en français. En la página 397 figura un resumen en español.

Introduction

Intestinal schistosomiasis caused by *Schistosoma mansoni* is widespread throughout Africa, where it is currently endemic in 40 countries (*1*). Because its distribution is focal, the transmission is influenced by factors such as intermediate host snail distribution, patterns of environmental contamination with human excreta and water contact by humans (*1–3*). Parasite aggregation in space and within communities is also an important feature (*4, 5*). The public health significance of schistosomiasis is often underestimated because its distribution is focal and because severe disease follows only after many years of mildly symptomatic infections (*1, 6*). In addition, primary health care systems in Africa have to deal with many other health problems, with resources that are scarce and that need to be allocated in the most effective way (*7*). This explains why schistosomiasis control is often given a low priority and why national programmes are almost non-existent. At present, the large-scale identification of *S. mansoni* infection requires stool examination, which is labour intensive and generally cannot be integrated into routine health care activities (*1, 7*). Therefore, there is a great need for a rapid but accurate assessment of individuals and/or communities at highest risk of intestinal

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Ref. No. **99-0430**

schistosomiasis, so that control activities can be better focused (*8*).

The use of a simple self-administered questionnaire to identify communities at highest risk for *Schistosoma haematobium* infection has proved to be very effective in more than 10 African countries with different levels of endemicity (*9–14*). The success of the questionnaire approach for urinary schistosomiasis arises because *S. haematobium* is generally well recognized by a specific and sensitive symptom, the presence of blood in urine. Based on these experiences, WHO has developed guidelines for use in the control of schistosomiasis by district health managers (*15*). Recently, the questionnaire was also validated in Côte d'Ivoire, and consequently its use was recommended as a first step for the national community-based morbidity control programme (*13*).

The objective of the present study was to develop and validate a similar questionnaire for the rapid identification of individuals and/or communities at high risk from *S. mansoni* infection. It was realized that the use of simple anamnestic questions would be more problematic for *S. mansoni*, since the signs and symptoms indicating an infection generally show low sensitivities and specificities, and do not yet permit operational interventions. However, recent studies conducted in the Democratic Republic of the Congo (*11, 16*), Ethiopia (*17*), Côte d'Ivoire (*18*) and the United Republic of Tanzania (*19*) suggested that presence of blood in stools is a useful indicator and its diagnostic performance for the rapid screening of *S. mansoni* should be further investigated. The benefits of a rapid appraisal method would be considerable, especially if a single questionnaire would work for both schistosome species (*16*).

This article describes the design and validation of an *S. mansoni* questionnaire for large-scale use. Validation was performed by carrying out parasitological examinations in a random sample of schools where the questionnaire had been filled in, to determine the prevalence and intensity of *S. mansoni* infections. Since geohelminth infections could produce similar symptoms, and hence act as confounding factors (*18, 20–22*), their prevalences were also assessed. Prevalence of microhaematuria, an indirect indicator of *S. haematobium* infection (*23*) was also estimated to assess the frequency of mixed infections.

Materials and methods

Study area

The study was carried out in the region of Man, western Côte d'Ivoire, between January and June 1998. It is a known endemic area for intestinal schistosomiasis (*24–26*), but precise data on infection prevalence at the village level are only sparsely available. A recent study confirmed the high endemicity, with a cumulative infection prevalence of 92% derived from four repeated Kato–Katz readings in three villages (*18*).

The study area covers approximately 2500 km^2 with a total population estimated at 250 000 at the time of the survey. The town of Man (population, ca. 120 000) is located in the region's centre at an altitude of 320 m. Rice, coffee and cocoa are the most important cash crops and there is a small timber industry. Villagers in the rural areas are mainly engaged in subsistence farming, with dry and/or wet rice, cassava, maize, bananas and yams as their main crops. The mean annual precipitation is 1600 mm (*26*). There are two distinct seasons: a rainy season of 7 months from April to October, with peak rains in July and August, and a shorter dry season between November and March. The hydrography is dominated by rivers flowing south–north; the Ko and Nzo are the main rivers. The geographical coordinates (latitude and longitude) of the schools were collected with a hand-held GPS 45 (Garmin Corp., Lenexa, USA) and are displayed in Fig. 1.

Development and distribution of the questionnaire

The schoolchildren's questionnaire was based on the original French version, used previously in the Democratic Republic of the Congo (*11, 16*), and a slightly modified version that was successfully used in central Côte d'Ivoire (*13*). The questionnaire was finalized following focus group discussions with children heavily infected with *S. mansoni*, and after semi-structured interviews with three medical assistants in the region's main town, which emphasized in particular the symptoms of blood in stools and bloody diarrhoea (*18*). Finally, modifications were made after pre-testing in two schools. The final questionnaire consisted of a list of 12 different symptoms in French and 4 in the local Yacouba and Dioula languages, and a list of 9 different diseases (all in French). During preliminary testing it was found that children attending classes 1–3 had difficulties in responding to some of the questions, and it was decided to include only children attending classes 4–6 for large-scale use. Copies of the questionnaire can be obtained from the authors.

The questionnaire was accompanied by two separate forms: (i) the instructions for teachers and (ii) a blank class list. The teachers were asked to first read the instructions, then to fill in the names (in alphabetical order), sex and age of their pupils in the class list. After this, children were interviewed individually, in alphabetical order. The interview was conducted in an empty class room and answers were recorded as: "yes", "no" or "don't know". This procedure allowed us to analyse the data at both the individual and school levels, since individual answers could be related to individual parasitological results. The questionnaires were deposited at two regional education offices (Man 1 and Man 2) by the end of January 1998, and they were distributed by the existing administrative channels to all 134 primary schools.

Parasitological investigations and treatment of infected children

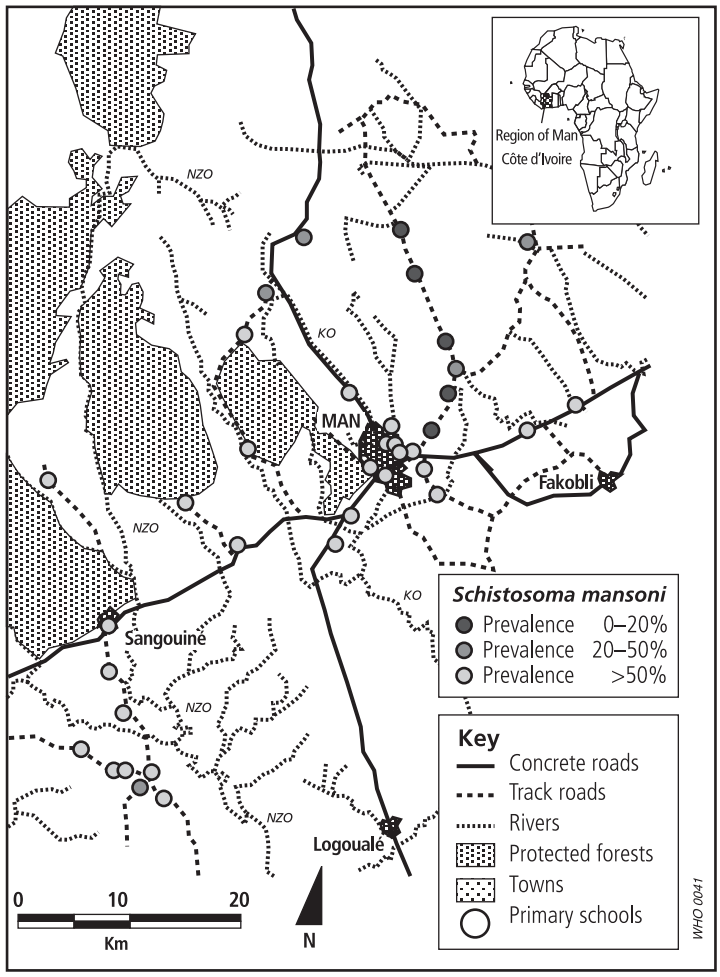
For parasitological validation, a simple random sample of 60 schools was drawn from the schools returning the questionnaires. The school directors were informed one day in advance that their school had been randomly selected for a parasitological validation of the questionnaire results. The objective of the study was explained, and the directors were assured that all children with intestinal parasites would benefit from free treatment. After obtaining teachers' consent, children were issued with a plastic container and invited to return the containers with a small portion of their morning stools on the day of the first survey. At the time of stool collection children were issued with another plastic container for a second stool sample on the following day.

A laboratory team consisting of seven people undertook field testing in 2–4 schools per day. Children's stool specimens were collected individually. A single 42-mg Kato–Katz thick smear was processed on the spot according to the method described by Katz et al. (*27*). The slides were brought to the central laboratory in Man and in the afternoon they were analysed by low-magnification light microscopy by one of five experienced technicians. The total number of eggs of *S. mansoni*, hookworms, *Ascaris lumbricoides* and *Trichuris trichiura* was counted. Quality control was carried out by the senior technician on 5–10% of the slides chosen at random.

On survey day, and always between 10:00 and 12:00, children were provided with another small plastic container for immediate urine collection. Reagent stick testing for microhaematuria was performed with Sangur sticks (Boehringer Mannheim GmbH, Mannheim, Germany). The sticks were briefly dipped into the fresh stirred urine sample and after 60 sec the colour change was read according to the manufacturer's instructions. The results were recorded as negative, 1+, 2+ or 3+.

All children who had at least one *S. mansoni* egg in any of the two Kato–Katz thick smears, or a reagent stick result of $\geqslant$ 1+, were treated with a single oral dose of praziquantel at the recommended standard dose of 40 mg per kg body weight (*1*). Infections with hookworms, *A. lumbricoides* and/or *T. trichiura* were treated with a single oral dose of albendazole (400 mg).

Fig. 1. **Map of the study area with the town of Man in the centre and the 60 schools where children were screened for *Schistosoma mansoni*. Prevalence of *S. mansoni* infection is shown by category: 0–20%, 20–50%, and >50%**



Data analysis

All data derived from the questionnaires and parasitological surveys were double entered and validated using the Epi Info software package (version 6.04, USD Inc., Stone Mountain, GA, USA). Daily infection prevalences of schistosomes and geohelminths were assessed in all the 60 schools. The cumulative infection prevalence was calculated for those children who provided two consecutive stool samples, using the arithmetic mean of the two samples. This was considered as the "gold standard" and was used for assessing the diagnostic performance of the questionnaire.

To assess the most reliable symptom(s) and/or disease(s) for predicting individual infection with *S. mansoni*, we performed a logistic regression analysis for those children who had two consecutive Kato–Katz readings, a reagent stick result on day 1 and complete questionnaire results. At the school level, Spearman rank correlation was calculated from the cumulative prevalence of *S. mansoni* infection and the questionnaire positivity rates in each school. The diagnostic performance of the questionnaire for identifying schools where the children were at high risk for *S. mansoni* infection was obtained by calculating the sensitivity, specificity and predictive values, including 95% confidence intervals (CI).

Results

Operational results

Within five weeks, correctly completed questionnaires were returned from 121 out of 134 schools

(90.3%) and a total of 12 227 children were interviewed individually. The median age of these children was 12 years (range, 6–17 years). There were significantly more boys (7489) than girls (4738) (χ^2 test, 1 degree of freedom (d.f.) = 313.2, $P<0.0001$), resulting in a male:female ratio of 1.58. The sex imbalance tended to increase with age.

For parasitological validation, a simple random sample of 60 schools was drawn from those that had classes 4–6 (n = 110 schools). In total, 6543 children were interviewed in this subsample. The median age was 12 years (range, 7–17 years), with a sex ratio of 1.57, and an average of 109 children were interviewed per school.

Schistosomes and geohelminths

Overall, 5047 children (77.1% of children interviewed) provided two consecutive stool specimens for Kato–Katz thick smears. *S. mansoni* was the commonest intestinal parasite, with a cumulative infection prevalence of 54.4%. Hookworm infections were underestimated by the Kato–Katz method, with a clearing time of several hours, since eggs are rapidly digested on the slides. Despite this underestimation, hookworms were the second most prevalent intestinal parasite, with an overall cumulative infection prevalence of 9.5%. Infections with *A. lumbricoides* and *T. trichiura* showed low cumulative prevalences of 5.5% and 4.1%, respectively (Table 1).

S. mansoni infections were divided into four categories: (i) no infection; (ii) light infection: 1–100 eggs per gram (epg) of stool; (iii) moderate infection: 101–400 epg; and (iv) heavy infection: >400 epg. The results obtained from the first and second Kato–Katz readings, as well as the cumulative results, are presented in Table 2. Daily infection prevalences were 45.0% and 45.8%, respectively, for the first and second Kato–Katz readings; and the prevalence of daily intensities of >100 epg was 28.1% and 28.5%, respectively. The cumulative prevalence of this intensity level was 31.0%. There was a large range in infection prevalence measured among the 60 schools, from 4.0% to 94.0%. There was also a large range (1.6–79.5%) in the prevalence of infections >100 epg. Boys (59.4%) were significantly more often infected with *S. mansoni* than girls (46.7%, χ^2 test, 1 d.f. = 76.2, $P<0.0001$). Among infected children the median infection intensity of boys (156 epg) was significantly higher than that of girls (108 epg, χ^2 test, 1 d.f. = 13.4, $P<0.001$).

A total of 5967 children provided a urine sample on day 1, and in 328 cases (5.5%) the reagent stick result was positive. Since reagent stick testing has a specificity well below 100%, most of these are likely to be false positives. Initially, it was planned to screen all children for microhaematuria on two consecutive days. However, after screening in 40 schools and obtaining such a low point prevalence, it was obvious that *S. haematobium* infections were very rare in the area and it was decided that the cost of a second reagent stick testing was not justified.

Table 1. **Overall cumulative results of *Schistosoma mansoni* and geohelminth infections from 60 schools in the region of Man, western Côte d'Ivoire**[a]

	No. positive	Infection prevalence (%)
Kato 1 and Kato 2 (n = 5047)		
Schistosoma mansoni	2747	54.4 (53.0–55.8)[b]
Hookworm	480	9.5 (8.7–10.4)
Ascaris lumbricoides	276	5.5 (4.9–6.1)
Trichuris trichiura	205	4.1 (3.5–4.6)
Reagent stick day 1 (n = 5967 children)	328	5.5 (4.9–6.1)

[a] The parasite data were derived from two consecutive Kato–Katz thick smears. The prevalence of microhaematuria (an indirect indicator for *S. haematobium*) was determined using Sangur sticks (see Materials and methods).

[b] Figures in parentheses are 95% confidence intervals.

Association between questionnaire and parasitological data at the individual level

Two consecutive stool samples, a urine reagent stick testing result on day 1, and complete answers to the questionnaire were obtained from 4788 children. For these children, logistic regression analysis at the individual level confirmed that an infection with *S. mansoni* was significantly associated with sex (adjusted odds ratio: 1.14, 95% CI: 1.10–1.18, $P<0.001$) and age (adjusted odds ratio: 0.65, 95% CI: 0.58–0.74, $P<0.001$) (Table 3). Children infected with *S. mansoni* were more likely also to have a hookworm infection (adjusted odds ratio: 1.30, 95% CI: 1.06–1.60, $P<0.001$). No such positive associations were found for *A. lumbricoides* and *T. trichiura*. It was also found that children infected with *S. mansoni* were more likely to have low-level microhaematuria (adjusted odds ratio: 1.91, 95% CI: 1.45–2.53, $P<0.001$).

Multivariate analysis identified "blood in stools" and "bloody diarrhoea" as those symptoms having the strongest association with an *S. mansoni* infection. The adjusted odds ratios were 1.59 (95% CI: 1.38–1.83, $P<0.001$) and 1.34 (95% CI: 1.14–1.58, $P<0.001$), respectively (Table 3). The answer "yes" to "do you have schistosomiasis?" was given significantly more often by children infected with *S. mansoni*, but the adjusted odds ratio was low. There was also a significant odds ratio between reported skin disease and infection with *S. mansoni*, but this may be a chance finding, which would not be surprising given the number of variables that were investigated. No significant odds ratios were found between *S. mansoni* infection and reported abdominal pain, reported presence of worms in the faeces, or reported diarrhoea (Table 3).

Association between questionnaire and parasitological data at the school level

The Spearman rank correlation test revealed significant associations between the cumulative school

infection prevalences of *S. mansoni* and prevalences of reported bloody diarrhoea ($\theta = 0.39$, $P = 0.002$), reported blood in stools ($\theta = 0.32$, $P = 0.014$) and reported schistosomiasis ($\theta = 0.33$, $P = 0.011$) (Table 4) (see Fig 2a–c).

Preliminary analysis of the data indicated that some schools had very high male:female ratios. Since infections occurred more often among boys, we additionally investigated whether extreme sex ratios could affect the relationship between infection prevalence and reported symptoms. We gradually removed schools from the data set, starting with schools with the highest sex ratios, and repeated the analysis at each step. This process revealed that schools with lower sex ratios had higher degrees of correlation between the prevalences of *S. mansoni* infections and those of reported blood in stools. For example, schools with a sex ratio of $\leqslant 2$ had a Spearman rank correlation coefficient of 0.48 ($n = 41$, $P = 0.002$), and those with a sex ratio $\leqslant 1.6$ had a correlation coefficient of 0.56 ($n = 27$, $P = 0.002$). The improvement in the relationship is shown in Fig. 2d, which displays data from schools with a sex ratio $\leqslant 1.6$. Interestingly, when sex-stratified analysis was conducted, the correlations were not improved. This suggests that it was not the gender per se that led to weak correlations, but rather that schools with a high sex ratio were special in some way.

Spearman rank correlation analysis was also performed with different levels of *S. mansoni* infection intensities. Interestingly, *S. mansoni* infection prevalence was better correlated with reported blood in stools, bloody diarrhoea or reported schistosomiasis, than with different intensity measures of infection (Table 4). When we repeated the analysis with the reduced data set (schools with sex ratio $\leqslant 1.6$) there was an increase in the correlation coefficient between the prevalence and intensity of parasites, and the reported blood in stools or bloody diarrhoea. In contrast, the correlation coefficients were significantly reduced for reported schistosomiasis (Table 4).

Diagnostic performance of the questionnaire at the school level

The first step in calculating the diagnostic performance of the schoolchildren's questionnaire was to choose a detection threshold, i.e. a prevalence of *S. mansoni* infection above which the school would be termed "high risk". Based on the findings of Montresor et al. (*28*), we used a threshold of 50%. For this threshold, we then determined the positive rates of reported symptoms and reported diseases; these rates were 22% for reported blood in stools, 14% for reported bloody diarrhoea and 4% for reported schistosomiasis.

The sensitivity, specificity and predictive values for reported blood in stools, reported bloody diarrhoea and reported schistosomiasis are given in Table 5. The two reported symptoms, blood in stools and bloody diarrhoea, showed exactly the same diagnostic performance, with a sensitivity of 88.2% (95% CI: 71.6–96.2%), a specificity of 57.7% (95% CI: 37.2–76.0%), a positive predictive value of 73.2% (95% CI: 56.8–85.2%) and a negative predictive value of 78.9% (95% CI: 53.9–93.0%). Reported schistosomiasis resulted in slightly lower values: positive predictive value: 68.6% (95% CI: 50.6–82.6%); and negative predictive value: 60.0% (95% CI: 38.9–78.2%).

Table 2. **Point and cumulative prevalence of *Schistosoma mansoni* infection, as assessed by two consecutive Kato–Katz thick smears**

		Prevalence (%)		
		Kato 1 ($n = 5811$)	Kato 2 ($n = 5493$)	Cumulative Kato 1 and Kato 2 ($n = 5047$)
All infections		45.0	45.8	54.4
All infections > 100 epg[a]		28.1	28.5	31.0
Children's infection status (epg)[a]				
Negative	(0)	55.0	54.2	45.6
Light infection	(1–100)	16.9	17.3	23.4
Moderate infection	(101–400)	14.7	15.3	16.9
Heavy infection	(> 400)	13.4	13.2	14.1

[a] epg = eggs per gram of stool.

Table 3. **Assessment of potentially confounding factors for predicting *Schistosoma mansoni* infection[a]**

Variable	Adjusted odds ratio	Likelihood ratio statistics	*P*-value
Children surveyed			
Sex	1.14 (1.10–1.18)[b]	49.08	< 0.001
Age	0.65 (0.58–0.74)	48.00	< 0.001
Intestinal parasite			
Hookworm	1.30 (1.06–1.60)	6.14	0.013
Ascaris lumbricoides	0.85 (0.66–1.09)	1.65	0.199
Trichuris trichiura	0.99 (0.73–1.34)	0.00	0.952
Reported symptoms			
Blood in stools	1.59 (1.38–1.83)	41.90	< 0.001
Bloody diarrhoea	1.34 (1.14–1.58)	12.66	< 0.001
Schistosomiasis	1.32 (1.04–1.66)	5.43	0.020
Skin disease	1.18 (1.01–1.37)	4.26	0.039
Worm in faeces	1.12 (0.98–1.27)	2.89	0.089
Abdominal pain	1.03 (0.91–1.17)	0.25	0.619
Diarrhoea	1.02 (0.89–1.16)	0.06	0.800

[a] Logistic regression modelling at the individual level was carried out to assess potential confounders of the association between an infection with *S. mansoni* or other intestinal parasites, and the best performing reported symptoms ($n = 4788$ children).

[b] Figures in parentheses are 95% confidence intervals.

Discussion

Counting eggs in stool samples is currently the most widely used epidemiological approach for quantify-

Table 4. **Spearman rank correlation analysis at the school level for reported blood in stools, reported diarrhoea and reported schistosomiasis, for five different criteria for *Schistosoma mansoni* infection.** The criteria used were infection prevalence and four different intensity measures

	Reported blood in stools		Reported bloody diarrhoea		Reported schistosomiasis	
	θ	***P*-value**	θ	***P*-value**	θ	***P*-value**
All schools ($n = 60$)						
Infection prevalence	0.32	0.014	0.39	0.002	0.33	0.011
Infection intensity > 100 epg[a]	0.26	0.047	0.33	0.010	0.29	0.022
Infection intensity > 400 epg	0.16	0.237	0.33	0.010	0.33	0.010
Arithmetic mean intensity	0.21	0.101	0.28	0.030	0.33	0.010
Geometric mean intensity	0.30	0.021	0.37	0.004	0.34	0.008
Only schools with sex-ratio $\leqslant$ 1.6 ($n = 27$)						
Infection prevalence	0.56	0.002	0.43	0.024	0.05	0.820
Infection intensity > 100 epg	0.62	0.001	0.39	0.042	0.06	0.764
Infection intensity > 400 epg	0.59	0.001	0.45	0.018	0.22	0.271
Arithmetic mean intensity	0.60	0.001	0.48	0.012	0.18	0.373
Geometric mean intensity	0.62	0.001	0.45	0.018	0.09	0.641

[a] epg = eggs per gram of stool.

Fig. 2. **Relationship between the cumulative school infection prevalence of *Schistosoma mansoni* and the prevalence of reported symptoms. a) reported blood in stools (all schools, $n = 60$); b) reported bloody diarrhoea (all schools, $n = 60$); c) reported schistosomiasis (all schools, $n = 60$); d) reported blood in stools (only [those] schools with a male: female ratio $\leqslant$ 1.6, $n = 27$)**

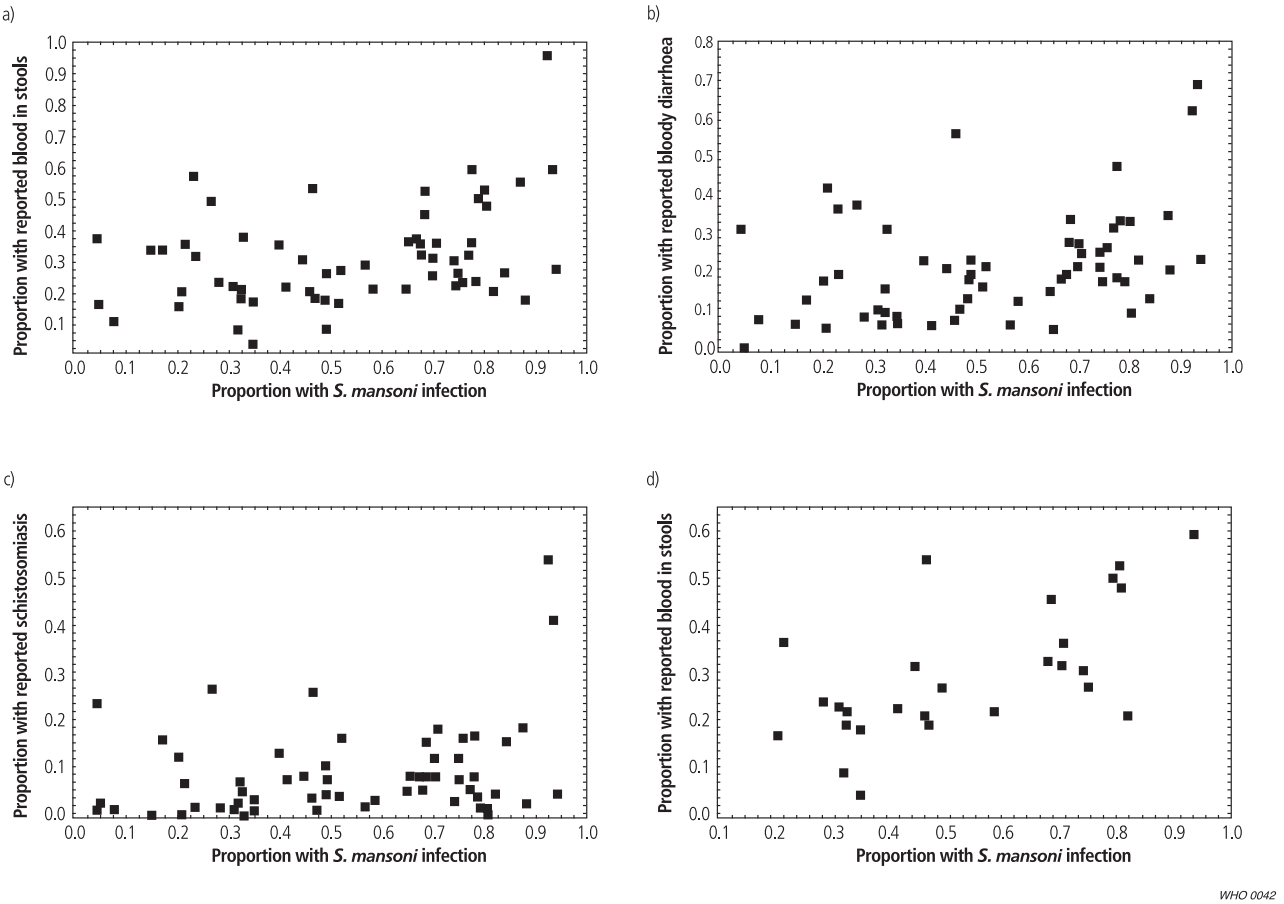


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Table 5. **Diagnostic performance of reported symptoms and/or diseases indicating an infection with *Schistosoma mansoni*.** The threshold for detecting a high-risk school was set at an *S. mansoni* infection prevalence of 50% (*28*)

Reported symptoms and/or diseases	Questionnaire threshold (%)	Diagnostic performance (%)			
		Sensitivity	Specificity	Positive predictive value	Negative predictive value
Blood in stools	22	88.2 (71.6–96.2)[a]	57.7 (37.2–76.0)	73.2 (56.8–85.2)	78.9 (53.9–93.0)
Bloody diarrhoea	14	88.2 (71.6–96.2)	57.7 (37.2–76.0)	73.2 (56.8–85.2)	78.9 (53.9–93.0)
Schistosomiasis	4	70.6 (52.3–84.3)	57.7 (37.2–76.0)	68.6 (50.6–82.6)	60.0 (38.9–78.2)

[a] Figures in parentheses are 95% confidence intervals.

ing the prevalence and intensity of infection due to *S. mansoni* or geohelminths. The Kato–Katz method (*27*) is relatively easy to perform, requires only a minimum of equipment and is suitable in many situations for direct application in the field. Most studies analyse single thick smears, but this gives reliable estimates of the "true" infection prevalence of *S. mansoni* only in high endemicity areas (*29, 30*). When emphasis is placed on individual diagnosis, it is recommended that stool specimens be collected over several consecutive days; however, this is operationally difficult and costly, and is clearly not feasible for large-scale screening (*31*). In the present study, schoolchildren's stool specimens were collected over two consecutive days. This allowed us to detect an additional 20% of children who were infected with *S. mansoni*, but who tested egg-negative on a single occasion (Table 2). Testing on additional days would have been desirable, but operationally this was not feasible given the large scale of the study.

The use of questionnaires is a promising alternative to egg counting for rapid and low-cost identification of individuals and/or communities at highest risk of schistosomiasis. Questionnaires have been used successfully to screen for *S. haematobium* infection in Africa, with diagnosis at the community level as the main objective (*9–11, 13, 14, 16, 32–34*). There is some recent evidence from the United Republic of Tanzania that self-reporting of blood in urine may also be useful for individual diagnosis of *S. haematobium* infection (*12, 19, 35*). In the case of *S. mansoni,* a number of epidemiological studies have assessed clinical signs and reported symptoms that may indicate an infection. In some areas of sub-Saharan Africa, for example, a significant association has been found between *S. mansoni* infection and the presence and/or reports of blood in the stools (*18, 20, 22, 36–43*). However, all these studies revealed low-to-moderate sensitivities, and hence low-to-moderate negative predictive values.

The present study is probably the largest of its kind yet undertaken to evaluate the use of questionnaires for rapid screening of *S. mansoni* infection, with emphasis on individual and community diagnosis. The study confirmed that individuals infected with *S. mansoni* reported blood in stools significantly more often; however the adjusted odds ratio was only 1.59 (Table 3). The sensitivity and negative predictive value of reported blood in stools were therefore modest: 37% and 51%, respectively. These values are within the range estimated in earlier work (*18, 20, 22, 36–43*). Previous studies also found that an infection with *S. mansoni* is often significantly associated with the presence of diarrhoea, particularly bloody diarrhoea (*20, 44, 45*). Again, our results lie within the range of values reported by these workers, but as with reported blood in stools, sensitivities and negative predictive values were generally low to moderate.

It has been suggested that low sensitivities of reported blood in stools and reported bloody diarrhoea could be partly explained by the confounding effect of other intestinal parasites (*20–22*). In a multivariate analysis in the same area, other intestinal parasites did not act as confounders (*18*). Most recently, attributable risk calculations revealed that a substantial fraction of bloody stool episodes could be attributed to an infection with *S. mansoni* (*46, 47*), indicating that other parasites are unlikely to affect the relationship to an extensive degree.

We also found a significant correlation between *S. mansoni* infection and reported schistosomiasis at the individual level, but the adjusted odds ratio of 1.32 was very low (Table 3). Interestingly, a previous study in the Democratic Republic of the Congo showed a much better correlation between individual infection with *S. mansoni* and reported schistosomiasis (*16*). We found no significant correlation between an *S. mansoni* infection and reported diarrhoea (Table 3), in contrast to the results reported by Gryseels (*45*).

Analysis at the school level revealed that prevalences of reported bloody diarrhoea and reported blood in stools were both significantly correlated with the cumulative infection prevalence of *S. mansoni* (Table 4). Studies in the Democratic Republic of the Congo (*16*), Ethiopia (*17*) and the United Republic of Tanzania (*19*) also found a positive correlation between the prevalence of reported blood in stools and infection prevalence, based on analysis of single stool samples. When we included all the study schools in our analysis, the correlation coefficients were low, because of considerable scatter in the data. By removing schools with high male:female ratios, we were able to improve

considerably the correlation coefficients, indicating that schools with a bias towards males had different characteristics than the rest of the schools (Table 4). We were unable to identify the nature of these differences, but our results nonetheless indicate that they are important and need to be studied in more detail.

In light of our results, it may be that the questionnaire we used was not sufficiently sophisticated, and could be improved by the addition of questions focusing on risk factors for infection. A wider range of factors was investigated in a study in Brazil, where migratory status, frequent reported water contacts, history of swimming and history of fishing correlated significantly with an *S. mansoni* infection (*48*). However, the diagnostic performance of such explanatory variables may change considerably from one community to another, and their generalization might be difficult (*49*). A study in China considered not only multiple risk factors but also multiple symptoms, and found that a combination of six key variables resulted in sensitivities and specificities above 90% for identifying infected children (*50*). One of the key factors was a previous treatment history for schistosomiasis. This might explain the good diagnostic performance, since the community in question had been exposed to schistosomiasis and its control for a long time and had a clear perception of the disease. However, a question about previous treatment history would have been unhelpful in the present study, as treatment had never been carried out before the study took place. This is likely to be the case in many other African countries.

We conclude that there is still a considerable amount of research needed to develop a rapid, low-cost and reliable screening tool for *S. mansoni* infection, for large-scale use. There seems to be firm evidence that anamnestic questions alone are insufficient for identifying individuals and/or communities at high risk of *S. mansoni* infection. We therefore argue that a combination of reported symptoms and risk factors could increase the diagnostic performance of questionnaires. It is therefore also important to decide whether the emphasis should be placed on individual (for clinical practice) or community (for public health) diagnosis, as recently discussed by Barreto (*51*). ■

Acknowledgements

We thank the two school inspectors (R. Agbacou, D. Blamatié), their secretaries, all the school directors and teachers of classes 4–6 and all the pupils who responded to the questions and provided stool and urine specimens. We greatly acknowledge the excellent collaboration of two laboratory technicians, A. Fondio and N. N'Dri. Thanked also are N. N'Guessan for help in the field work, R. Kpon for data entry and J.M. Jenkins for making useful comments on the manuscript. This investigation received financial support from the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR), the Swiss Agency for Development and Cooperation and the Roche Research Foundation. *J.U.* was supported by the Rudolf Geigy Foundation, *E.K.N.* by the Swiss Academy of Natural Sciences and *C.L.* by the Swiss National Science Foundation (PROSPER grant 32-41632.94).

Résumé

Côte d'Ivoire : dépistage rapide de *Schistosoma mansoni* au moyen d'un questionnaire distribué dans les écoles

La schistosomiase (bilharziose) est une maladie qui montre une répartition en foyers et, si l'on veut tirer le meilleur parti possible des moyens de lutte disponibles, il est important de les consacrer en priorité aux individus et/ou aux communautés les plus touchés. Des approches rapides de détection des cas à moindre coût, comme par exemple de simples questionnaires scolaires, sont donc indispensables. Dans un foyer de forte endémie de schistosomiase à *S. mansoni* situé dans l'ouest de la Côte d'Ivoire, un questionnaire a été distribué dans 134 écoles primaires. Cinq semaines après, 121 écoles (90,3 %) avaient répondu – 12 227 élèves avaient été interrogés individuellement. On a cherché à obtenir une confirmation parasitologique dans 60 écoles tirées au hasard et les selles de 5047 élèves ont été analysées par la méthode de Kato-Katz, pendant deux jours consécutifs. La prévalence globale de *S. mansoni* a été de 54,4 %. De plus, les élèves infectés par *S. mansoni* ont répondu plus fréquemment avoir eu du « sang dans les selles », une « dysenterie » et une « bilharziose » que les autres. Dans les écoles, le coefficient de corrélation des rangs de Spearman a montré que la prévalence globale de *S. mansoni* présentait une corrélation statistique très significative avec la fréquence des réponses positives aux questions suivantes : « As-tu eu de la dysenterie depuis un mois ? » ($p = 0,002$), « As-tu eu du sang dans les selles depuis un mois ? » ($p = 0,014$) et « As-tu eu la bilharziose depuis un mois ? » ($p = 0,011$). Les symptômes « dysenterie » et « sang dans les selles » ont donné les meilleurs résultats au plan diagnostique (sensibilité : 88,2 %, spécificité : 57,7 %, valeur prédictive positive : 73,2 %, valeur prédictive négative : 78,9 %). Ces deux symptômes sont donc les plus fiables pour l'identification rapide des individus et/ou des communautés présentant un risque élevé de morbidité due à *S. mansoni*.

Resumen

Detección rápida de *Schistosoma mansoni* en el oeste de Côte d'Ivoire mediante un cuestionario escolar simple

La esquistosomiasis presenta una distribución focal, por lo que, para que los medios de lucha disponibles tengan la mayor eficacia posible, es importante centrarse de manera prioritaria en las comunidades o los individuos más afectados. Con ese fin es indispensable servirse de medios rápidos y baratos tales como los cuestionarios escolares simples. En el presente estudio se utilizaron ese tipo de cuestionarios en una zona del oeste de Côte d'Ivoire donde *S. mansoni* es endémico. Se distribuyeron los cuestionarios en 134 escuelas, 121 de las cuales (90,3%) los devolvieron correctamente cumplimentados; en total se interrogó individualmente a 12 227 alumnos. Por otra parte se analizó la presencia de *S. mansoni* practicando exámenes microscópicos en 60 escuelas elegidas al azar: se aplicó la técnica de Kato-Katz (frotis grueso de materia fecal) a muestras de heces de dos días consecutivos de 5047 alumnos. El 54,4% de los individuos de los que procedía el total de las muestras estaban infectados por *S. mansoni*. Además, los alumnos infectados por *S. mansoni* habían notificado con frecuencia significativamente más alta que los no infectados la presencia de «sangre en las heces», o haber sufrido «disentería» o «esquistosomiasis». En las escuelas, el coeficiente de correlación de rangos de Spearman mostró que la prevalencia general de *S. mansoni* se correlacionaba significativamente con la notificación de disentería ($P = 0{,}002$), la notificación de presencia de sangre en las heces ($P = 0{,}014$) y la notificación de esquistosomiasis ($P = 0{,}011$). Los síntomas de disentería y de presencia de sangre en las heces lograron el mejor resultado diagnóstico (sensibilidad: 88,2%; especificidad: 57,7%; valor predictivo positivo: 73,2%; valor predictivo negativo: 78,9%). El estudio, probablemente el más amplio de ese tipo realizado en África, reveló que los cuestionarios tienen un poder diagnóstico moderado a efectos de identificación de los individuos y/o las comunidades con alto riesgo de presencia de *S. mansoni*.

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