Sustaining the Control of *Schistosoma mansoni* in Western Côte d'Ivoire: Baseline Findings before the Implementation of a Randomized Trial

Rufin K. Assaré, Eveline Hürlimann, Mamadou Ouattara, Nicaise A. N'Guessan, Yves-Nathan T. Tian-Bi, Ahoua Yapi, Patrick K. Yao, Jean T. Coulibaly, Stefanie Knopp, Eliézer K. N'Goran, and Jürg Utzinger*

Swiss Tropical and Public Health Institute, Basel, Switzerland; University of Basel, Basel, Switzerland; Unité de Formation et de Recherche Biosciences, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire; Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire; Wolfson Wellcome Biomedical Laboratories, Department of Life Sciences, Natural History Museum, London, United Kingdom

Abstract. We report baseline findings before the implementation of a 4-year intervention trial designed to assess the impact of three different school-based treatment schedules with praziquantel to sustain the control of intestinal schistosomiasis. The baseline survey was conducted in 75 schools of western Côte d'Ivoire previously identified with moderate *Schistosoma mansoni* endemicity (prevalence: 10–24% in children aged 13–14 years). Three stool samples collected over consecutive days were subjected to duplicate Kato-Katz thick smears each. A questionnaire was administered to collect village-specific information that is relevant for schistosomiasis transmission. Overall, 4,953 first graders (aged 5–8 years) and 7,011 school children (aged 9–12 years) had complete parasitologic data. The overall prevalence of *S. mansoni* was 5.4% among first graders and 22.1% in 9- to 12-year-old children. Open defecation was practiced in all villages. The current baseline findings will be important to better understand the dynamics of *S. mansoni* prevalence and intensity over the course of this trial that might be governed by village characteristics and specific treatment interventions.

INTRODUCTION

Schistosomiasis, a water-associated disease, remains a relevant public health problem in the tropics and subtropics. Indeed, schistosomiasis affects more than 250 million people with an estimated global burden of 3.9 million disability-adjusted life years.^{1,2} In 2013, some 121 million school-aged children were considered at risk of schistosomiasis, with more than 90% of them concentrated in sub-Saharan Africa.³ In this region, approximately one-third of the schistosomiasis cases are caused by the species *Schistosoma mansoni*.⁴

Since the mid-1980s, the World Health Organization (WHO) recommends preventive chemotherapy, that is, the large-scale population-based mass drug administration (MDA) of praziquantel, as the main pillar of schistosomiasis control.⁵ The target is to treat at least 75% and up to 100% of school-aged children at risk of schistosomiasis with praziquantel.^{6,7} In 2012, numerous institutions and private organizations approved and decided to support this goal.⁸ According to WHO guidelines, the frequency of treatment in the school-aged population (children aged 5–14 years regardless of whether they are enrolled in school) is 1) once every year in high-risk communities (prevalence: $\geq 50\%$ measured by parasitologic methods); 2) once every second year in moderate-risk communities (prevalence: 10–49%); and 3) twice during primary school age in low-risk communities (prevalence: $< 10\%$).⁷ To strengthen the current evidence base for program decisions about preventive chemotherapy to gain and sustain the control of schistosomiasis, the Schistosomiasis Consortium for Operational Research and Evaluation (SCORE; <http://score.uga.edu/>) designed a multi-country study with several treatment arms implemented over multiple years.^{9,10}

In contrast to other schistosomiasis-endemic parts of the world where considerable progress in the fight against schistosomiasis has been achieved over the past decades

(e.g., Brazil and China),^{11,12} control efforts in sub-Saharan Africa were less successful, partially explained by low coverage and rapid reinfection rates after MDA campaigns.^{3,13,14} To deepen our understanding why schistosomiasis control interventions, including preventive chemotherapy, are more or less successful, it is important to consider determinants of disease transmission, such as hydrogeographic features, access and use of clean water, improved sanitation and hygiene, and socioeconomic characteristics of local communities.^{15–18}

This article describes the baseline parasitologic situation and village characteristics of the 75 communities in western Côte d'Ivoire that were randomized to one of the three intervention arms of a SCORE study to determine the effect of different treatment schedules to sustain schistosomiasis control in moderate endemicity areas.⁹ In each school, some 100 children (usually 9–12 years) submitted three consecutive stool samples that were subjected to duplicate Kato-Katz thick smears each. We also compared our *S. mansoni* prevalence data with results from a previous large-scale eligibility survey while screening 50 children aged 13–14 years with a single stool sample subjected to duplicate Kato-Katz thick smears. We show how fragile the categorization into risk communities is, based on simple prevalence thresholds, as it depends on the age of subjects screened, sampling efforts, diagnostic approach, among other issues.

MATERIALS AND METHODS

Ethics statement. Ethical approval for this study was obtained from the ethics committees of the Ministry of Public Health in Abidjan, Côte d'Ivoire (reference no. 1994 MSHP/CNER) and the 'Ethikkommission beider Basel' in Basel, Switzerland (reference no. EKBB 297/10). The purpose of the study was explained to education and health authorities. An information sheet was delivered to participating school children and written informed consent was obtained from their parents or guardians. At the end of the baseline parasitologic survey, all children aged 5–15 years living in the study area were offered praziquantel treatment (40 mg/kg) provided free of charge by

*Address correspondence to Jürg Utzinger, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland. E-mail: juerg.utzinger@unibas.ch

FIGURE 1. Study area in western Côte d'Ivoire showing schools surveyed at the eligibility survey (June–August 2011 and December 2011) and at the baseline survey (December 2011 to February 2012) in blue circles.

the “Programme National de Lutte contre la Schistosomiase, les Géohelminthiases et la Filariose Lymphatique.” Praziquantel treatment was given to children using the WHO dose pole.¹⁹

Study area and population. As shown in Figure 1, the study is being implemented in four regions of western Côte d'Ivoire: Cavally, Guémon, Tonkpi, and Haut-Sassandra, extending from 06°28'47.5" to 07°52'10.0" N latitude and from 06°44'09.8" to 08°21'30.0" W longitude. Previous studies showed that *S. mansoni* is highly endemic in this area, while *S. haematobium* coexists in some areas.^{20–24} Previous malacologic surveys revealed that *Biomphalaria pfeifferi* and *Bulinus globosus* act as intermediate host snail of *S. mansoni* and *S. haematobium*, respectively.^{22,25–28} In a cross-sectional survey carried out between June 19 and August 22, 2011, and between December 4 and 22, 2011, to identify communities eligible to participate in this SCORE study, the *S. mansoni* prevalence was determined in 264 schools.⁹ In each school, 50 children aged 13–14 years were examined by duplicate Kato-Katz thick smears on a single stool sample. *S. mansoni* prevalence rates above 24% were mainly observed in Tonkpi region, while schools with prevalence of infection ranging between 10% and 24% were predominantly found in Gomon, Cavally, and Haut-Sassandra.²⁹ Those 75 villages where the *S. mansoni* prevalence ranged between 10% and 24% and that fulfilled other inclusion criteria were eligible for the SCORE trial. Villages were randomized into one of three treatment arms. This article describes the baseline situation in the 75 schools including important village characteristics.

Field and laboratory procedures. The baseline survey in the 75 schools was conducted from December 4 to 22, 2011, and from January 26 to February 27, 2012. In the first step, teachers prepared lists with the name, sex, and age of chil-

dren enrolled in their classes. Subsequently, in each school, 100 children (usually aged 9–12 years) from grades 2–6 and up to 100 children from grade 1 were randomly selected from the lists. In case insufficient numbers of children were available in the desired age range, older children were invited to participate. The selected children received detailed information and an informed consent sheet, and they were asked to have the consent sheet signed by their parents or legal guardian.⁹ Children with written informed consent were given a 125-mL plastic container and asked to provide a portion of their own fresh morning stool the next day. First-grade children were asked for a single stool sample, while the other children were invited to submit stool samples on three consecutive days. Children's parents and guardians were asked to make sure that their children collected their own stool. Returned stool containers were collected and identified with unique codes by experienced fieldworkers and transferred to nearby laboratories for diagnostic work-up.

In the laboratories, stool samples were processed using the Kato-Katz technique, with a standard 41.7-mg plastic template.³⁰ From each stool sample, duplicate Kato-Katz thick smears were prepared on two microscope slides. After a clearing time of at least 60 minutes, the thick smears were examined by experienced laboratory technicians under a light microscope at low magnification. Eggs of *S. mansoni* and soil-transmitted helminths (*Ascaris lumbricoides*, hookworm, and *Trichuris trichiura*) were counted and recorded for each species separately. For quality control, 10% of the slides were randomly selected and reexamined by a senior laboratory technician. If there were discrepancies between the two results (e.g., positive versus negative result, or counts differing by more than 20%), the respective slides were read again and the results discussed until agreement was reached.

Assessment of village characteristics. In parallel to the parasitologic survey, a questionnaire on factors that might influence *S. mansoni* transmission was administered to school directors and village leaders. The questionnaire included six main sections pertaining to 1) demographics (i.e., village name, number of households and individuals); 2) water-related activities in the population (i.e., fishing, cleaning, and irrigated rice farming); 3) health system indicators (i.e., presence and type of health facility, availability and quality of praziquantel and artemisinin-based combination therapy [ACT]); 4) water bodies (i.e., number of perennial and seasonal water courses/stagnant water bodies); 5) water use (i.e., water sources used for drinking, washing, and bathing); and 6) defecation behavior (i.e., open defecation, availability and use of sanitation facilities).

Statistical analysis. Data were entered into a Microsoft Excel workbook 2010 (Microsoft Corporation, Redmond, WA). Statistical analyses were done with STATA (version IC13.1; Stata Corporation, College Station, TX). The prevalence of *S. mansoni* infection from the eligibility survey was estimated based on the results from duplicate Kato-Katz thick smears from a single stool sample from children aged 13–14 years.⁹ For the current analysis of the baseline survey, two groups of children were considered: 1) all children aged 9–12 years who had at least four Kato-Katz thick smears examined after three consecutive days of stool sampling and 2) all first-grade children who provided a single stool sample and had one or two Kato-Katz thick smears examined. Two different prevalence estimates were calculated for the 9- to 12-year-old

children at the baseline survey: 1) to render the sampling effort and prevalence comparable to the eligibility survey, the *S. mansoni* prevalence was calculated based on duplicate Kato-Katz thick smear results from the first stool sample and 2) to allow for a more accurate prevalence estimate, the *S. mansoni* prevalence was calculated from a minimum of four Kato-Katz thick smears from at least two consecutive stool samples. For the first-grade children, the *S. mansoni* prevalence was estimated based on at least one Kato-Katz thick smear from the single stool sample. Low-, moderate-, and high-endemicity areas were defined according to WHO⁷ at prevalence thresholds of < 10%, 10–49%, and ≥ 50%, respectively, and according to SCORE at prevalence thresholds of < 10%, 10–24%, and > 24%, respectively.^{6,9}

The arithmetic mean (AM) number of eggs per gram of stool (EPG) for *S. mansoni* was calculated from all available Kato-Katz thick smear readings per individual. On the basis of AM EPGs of each individual, infection intensity was determined according to WHO guidelines: 1) light (1–99 EPG); 2) moderate (100–399 EPG); and 3) heavy infections (≥ 400 EPG).⁶

Water use and defecation behavior as coded in the questionnaire (i.e., never = 0, rarely = 1, often = 2, and always = 3) was simplified and used as a binary variable (i.e., 0 = not

practiced, ≥ 1 = practiced). In addition, mean prominence values based on the four code categories (sum of the observed code values divided by four) are provided.

RESULTS

Characteristics of the study population. As shown in Figure 2, a total of 12,431 children were invited to participate at the baseline survey. There were 7,478 children aged 9–12 years and 4,953 first graders. Among the 9- to 12-year-old children, 467 were excluded, because they did not match the specified age group ($N = 168$), failed to provide even a single stool sample ($N = 5$), or had less than four Kato-Katz thick smears ($N = 294$). A total of 6,694 children aged 9–12 years submitted a stool sample on day 1 and 6,384 and 6,402 stool samples were submitted on days 2 and 3, respectively. At least four Kato-Katz thick smear results were available from 7,011 children aged 9–12 years and at least one Kato-Katz thick smear was available from 4,953 first graders.

These two groups were included into the main analysis of the baseline survey. Their mean age was 10.5 years and 6.5 years, respectively, and the sex ratio for boys to girls was 1.4:1.0 and 1.3:1.0, respectively.

FIGURE 2. Study participation at the baseline survey conducted in 75 schools in western Côte d'Ivoire in December 2011 to February 2012.

TABLE 1

Prevalence and intensity of *Schistosoma mansoni* infection in first-year and 9- to 12-year-old school children and prevalence of soil-transmitted helminth infections at the baseline survey conducted between December 2011 and February 2012 of a SCORE study in western Côte d'Ivoire

Variable	First-year school children	9- to 12-year-old school children
No. of individuals examined	4,953	7,011
No. of children infected (%)		
<i>S. mansoni</i>	269 (5.4)	1,547 (22.1)
<i>Trichuris trichiura</i>	27 (0.6)	221 (3.2)
<i>Ascaris lumbricoides</i>	15 (0.3)	66 (0.9)
Hookworm	6 (0.1)	95 (1.4)
Intensity of <i>S. mansoni</i> infection*		
Arithmetic mean EPG (95% CI)	10 (6.7–13.4)	20.4 (17.3–23.4)
Light infection (%)	73.2	80.9
Moderate infection (%)	21.4	14.2
Heavy infection (%)	7.7	4.9

CI = confidence interval; EPG = eggs per gram of stool; SCORE = Schistosomiasis Consortium for Operational Research and Evaluation.

*Light infection, 1–99 EPG; moderate infection, 100–399 EPG; heavy infection, ≥ 400 EPG.

***S. mansoni* and soil-transmitted infections.** Table 1 summarizes *S. mansoni* prevalence and intensity of infection and prevalence of soil-transmitted helminths. Examination of at least four Kato-Katz thick smears per child revealed that among the 7,011 children aged 9–12 years, 1,547 (22.1%) were infected with *S. mansoni*. The prevalence ranged from 1.0% to 54.0% at the unit of the school and was significantly higher among boys (24.3%) than girls (18.8%) ($\chi^2 = 29.91$, $P < 0.001$). Among the 4,953 first graders, a *S. mansoni* infection was found in 269 children (5.4%). For this group, the prevalence at the unit of the school ranged between 0% and 20.9%. There was no significant difference by sex ($\chi^2 = 0.98$, $P = 0.321$).

In both age groups, the majority of children had light-intensity infections, but the proportions of children with heavy infections were higher in first graders compared with 9- to 12-year-old children (7.7% versus 4.9%). Among 9- to 12-year-old children, the overall prevalence of *T. trichiura*, hookworm, and *A. lumbricoides* was 3.2%, 1.4%, and 0.9%, respectively. The corresponding values among first graders were 0.6%, 0.1%, and 0.3% respectively.

***S. mansoni* prevalence at the eligibility and baseline surveys.**

The overall *S. mansoni* prevalence based on the results from duplicate Kato-Katz thick smears from a single stool sample was 15.8% (95% confidence interval [CI], 14.8–16.8%) in the 12,110 children aged 13–14 years who participated in the eligibility survey and 13.0% (95% CI, 11.4–14.7%) in the 6,694 children aged 9–12 years who were surveyed at day 1 of the baseline survey. Considering the results of at least four Kato-Katz thick smears from 7,011 children, the overall *S. mansoni* prevalence at baseline was 22.1% (95% CI, 19.5–24.4%). Figure 3 shows that the average *S. mansoni* infection prevalence was lowest at the baseline survey considering duplicate Kato-Katz thick smears, followed by the eligibility survey, and the baseline survey with a diagnostic effort of at least quadruplicate Kato-Katz thick smears. Figure 4 shows the difference of the *S. mansoni* prevalence in the 75 schools compared between eligibility survey considering two Kato-Katz thick smears and baseline survey considering at least four Kato-Katz thick smears. Overall, the prevalence

FIGURE 3. *Schistosoma mansoni* prevalence in children aged 13–14 years at the eligibility survey and in children aged 9–12 years at the baseline (BL) survey. Eligibility: *S. mansoni* prevalence in 13- to 14-year-old children, according to results from duplicate Kato-Katz thick smears examined at the eligibility survey. BL1: *S. mansoni* prevalence in 9- to 12-year-old children, according to results from duplicate Kato-Katz thick smears examined from day 1 stool samples at the baseline survey. BL2: *S. mansoni* prevalence in 9- to 12-year-old children, according to the results from at least four Kato-Katz thick smears per child at the baseline survey.

in the eligibility survey was 39.9% lower than in the baseline survey. The prevalence of *S. mansoni* was significantly higher in five schools, while significantly lower rates were observed in three schools (Table 2). Among the 75 schools, 75 (100%) and 65 (86.7%) schools at the eligibility and baseline surveys, respectively, matched the WHO criteria of moderate endemicity (*S. mansoni* prevalence: 10–49%). In terms of target endemicity cut-offs defined by SCORE, by definition, all 75 schools fulfilled the target criteria of moderate

FIGURE 4. Dynamics of the *Schistosoma mansoni* prevalence in 75 schools from eligibility (points) to baseline (BL2: *S. mansoni* prevalence in 9- to 12-year-old children, according to results from at least four Kato-Katz thick smears per child at the baseline survey; arrow head) surveys. A 10–24% prevalence determined at the eligibility survey was the defined target endemicity level of moderate prevalence for this Schistosomiasis Consortium for Operational Research and Evaluation (SCORE) project. A prevalence of 10–49% is defined as moderate endemicity by criteria of the World Health Organization (WHO).

TABLE 2

Schools where significant changes have been observed in the *Schistosoma mansoni* prevalence comparing data from the eligibility and baseline surveys of a SCORE study in western Côte d'Ivoire

School	Eligibility		Baseline		Change (%)
	Prevalence (%)	95% CI	Prevalence (%)	95% CI	
Kassiapleu	10.0	1.4–18.6	29.0	20.0–38.0	+190.0
Gohouo-Zibiao	10.0	1.4–18.6	28.1	20.7–35.5	+180.8
Voungoué	11.4	1.6–21.1	33.7	23.9–43.5	+196.6
Glaou	18.0	7.0–29.0	39.7	31.7–47.8	+120.7
Kiélé I	18.0	7.0–29.0	37.3	30.7–44.3	+107.2
Pona 2	18.4	5.5–31.3	1.2	–0.6 to 3.8	–93.5
Pinhou 1	22.0	10.1–33.9	4.1	1.1–7.1	–81.5
Guinglo-Zia	22.5	10.3–34.6	5.2	1.7–8.7	–76.9

CI = confidence interval; SCORE = Schistosomiasis Consortium for Operational Research and Evaluation.

endemicity (*S. mansoni* prevalence: 10–24%) at the eligibility survey, but only 40 schools (53.4%) remained in this category in the baseline survey using at least quadruplicate Kato-Katz thick smear results, while 28 schools (37.3%) had prevalences above 24% and seven schools showed prevalences below 10%. Among the 28 schools that showed a *S. mansoni* prevalence above the SCORE preset maximum level at baseline, three had prevalences above 50%.

Demographic and environmental characteristics of local communities. Table 3 summarizes demographic and environmental determinants for *S. mansoni* infection in the study area. The overall estimated mean population size was 3,358 inhabitants, and there were 1,011 households. On average,

TABLE 3

Potential demographic, health system-related, and environmental risk factors for *Schistosoma mansoni* in the western part of Côte d'Ivoire

Variable	Mean	SE
No. of inhabitants/locality	3,358	409
No. of households/locality	1,011	291
No. of persons/household	6.5	0.6
Altitude (in meters)	339	13
	N	(%)
Main water contact-related activities		
Rice cultivation	71	95
Irrigated cultures	48	64
Fishing activities	54	72
Health system indicators		
Functional health center	30	40
Praziquantel availability	11	15
ACT availability	21	28
Water bodies		
Villages with PSW	57	76
No. of PSW: 1–3	39	52
No. of PSW: > 3	18	24
Villages with SSW	48	64
No. of SSW: 1–3	40	53
No. of SSW: > 3	8	11
Rivers		
Villages with PR	67	89
No. of PR: 1–3	47	63
No. of PR: > 3	20	27
Villages with SR	51	68
No. of SR: 1–3	42	56
No. of SR: > 3	9	12

ACT = artemisinin-based combination therapy; PR = permanent rivers or streams; PSW = permanent stagnant water bodies; SE = standard error; SR = seasonal rivers or streams; SSW = seasonal stagnant water bodies.

TABLE 4

Potential risk-related behaviors of school-aged children that govern *Schistosoma mansoni* infection in the western part of Côte d'Ivoire

Variable	Practiced		Mean prominence
	n	(%)	
Drinking water sources			
Open surface water	28	37	0.78
Cistern water	50	67	1.06
Well water	73	97	2.83
Tap water	10	13	0.29
Water sources used for washing			
Open surface water	48	64	1.38
Cistern water	67	89	1.49
Well water	72	96	2.49
Tap water	8	11	0.25
Water sources used for bathing			
Open surface water	47	63	1.24
Cistern water	62	83	1.33
Well water	72	96	2.67
Tap water	9	12	0.27
Defecation behavior			
Open defecation	75	100	2.80
Pit latrine	63	84	1.33
Improved latrine	1	1.3	0.01
Toilet/water closet	44	59	0.83

there were 6.5 inhabitants per household. The mean altitude was 339 m (standard error = 13 m) above mean sea level.

Rice cultivation was practiced in 71 (95%) communities. Thirty communities had a health facility in the village. ACT and praziquantel were available in 21 and 11 health facilities, respectively. Of note, all praziquantel stocks in the 11 health facilities were expired and also one-third (33%) of the ACT tablets in the 21 health facilities had passed their shelf life. There were 57 and 48 communities with permanent and seasonal stagnant water bodies, respectively. The corresponding values for rivers were 67 and 51.

Recreational and occupational risk-related behaviors for *S. mansoni* infection are shown in Table 4. Open defecation was practiced in all 75 communities and open surface water was used for washing in 48 communities and for bathing in 47 communities. Only 28 schools reported that open surface water was used for drinking. Among sanitation facilities, traditional pit latrines were the most common type (84%). Village authorities reported that the number of permanent rivers, streams, lakes, and ponds in the communities ranged from zero to 12 and that of seasonal water bodies ranged from zero to eight. Natural open freshwater bodies were predominantly used for washing and bathing. Well water was the most widely used type of water for drinking, washing, and bathing.

DISCUSSION

Preventive chemotherapy with praziquantel is the current mainstay of schistosomiasis control, and efforts are underway to scale-up treatment coverage to reach the goal of globally controlling schistosomiasis by the year 2020. WHO recommends specific frequencies of praziquantel administration to school-aged children, as function of prevalence level, usually assessed by standardized parasitologic tests such as the Kato-Katz technique for *S. mansoni* diagnosis. To determine the best strategy of preventive chemotherapy with praziquantel to sustain the control of schistosomiasis mansoni in moderate endemicity

settings (defined as prevalence in 13- to 14-year-old children ranging between 10% and 24%), a 4-year cluster randomized intervention trial is currently implemented in Côte d'Ivoire within the frame of a multi-country SCORE study.^{9,10} Here, we report the baseline parasitologic situation and village characteristics before the onset of the trial and show the challenge of categorizing communities based on a rapid assessment procedure with a relatively small sample size (50 children) and an insensitive diagnostic method (Kato-Katz technique).³¹

Examining single stool samples with duplicate Kato-Katz thick smears, we observed an overall *S. mansoni* prevalence of 15.8% in 13- to 14-year-old children at the eligibility survey. When 9- to 12-year-old children were examined with at least quadruplicate Kato-Katz thick smears at the baseline survey, the overall prevalence of *S. mansoni* was 22.1%. It follows that the overall prevalence of *S. mansoni* in school-aged children randomized into the 75 intervention schools in this large part of western Côte d'Ivoire can be considered as moderate according to WHO (10–49%) and SCORE (10–24%) prevalence thresholds. However, there were quite a number of schools in the baseline survey that had a prevalence above 24% compared with the eligibility survey (28 schools or 37.3% above the 24% prevalence threshold). Three of the schools actually had a prevalence of 50% and higher, and hence, must be considered as high-endemicity areas when using the more conservative WHO definition. On the other hand, seven schools (9.3%) showed a prevalence below 10% when comparing baseline with eligibility survey data.

The difference in the observed prevalence can be explained as follows. First, the children surveyed at baseline were slightly younger than those surveyed at the eligibility survey (mean age: 10.5 years versus 13.2 years). It is widely acknowledged that the prevalence and intensity of *Schistosoma* infection increase from early age, peaks around 8–15 years, and decrease again in adulthood.³² Second, the probability to detect a *S. mansoni* case with four or more Kato-Katz thick smears derived from two or three consecutive stool samples per individual is considerably higher than when only a single stool sample is examined with duplicate Kato-Katz thick smears. The effect of increased sampling effort on the diagnostic sensitivity of the Kato-Katz method has been documented before, and hence, it is strongly recommended to examine multiple stool samples over multiple days to obtain a reliable prevalence estimate of *S. mansoni* and other helminths, particularly in settings where infection intensities are low.^{33–37} Third, our results confirm that schistosomiasis is a focal disease; indeed, the prevalence of infection at the unit of the school showed considerable variation from one school to another.²⁹ Focality of *S. mansoni* is often explained with special occupational or recreational risk behaviors, proximity to open freshwater bodies that serve as habitat for intermediate host snails, and access to, and use of, sanitation facilities.^{38–42} In our study, for example, boys showed a higher infection prevalence than girls. This finding is in accordance with previous studies from Côte d'Ivoire and other parts of the world.^{21,43–45} The most likely explanation for a higher infection level in boys compared with girls is that boys are more actively exploring the environments of their settlements, including rivers and ponds, and hence, boys are more exposed to *S. mansoni* infection.⁴⁶

Previous research conducted in the village of Fagnampleu, in Tonkpi region, reported that prevalences of hookworm, *A. lumbricoides*, and *T. trichiura* were 60.0%, 3.4%, and 2.2%,

respectively.⁴⁷ Another study, which took place in 57 schools of the Man region, revealed prevalences of 30.5%, 2.2%, and 1.3% for hookworm, *A. lumbricoides*, and *T. trichiura* infection, respectively.⁴³ In our study, the corresponding values were 0.9%, 1.4%, and 3.2%, respectively. These results indicate that the prevalences of *A. lumbricoides* and *T. trichiura* were low in the study area. The unexpectedly low hookworm infection rate may be explained by the applied Kato-Katz procedure. In this study, the clearing time of the Kato-Katz thick smears between preparation and reading varied from 1 hour to several weeks, mainly explained by the large scale of the study with small mobile teams collecting and preparing Kato-Katz thick smears in the field with laboratory analysis done later on. Therefore, most of the hookworm eggs were dissolved and led to an underestimation of the actual prevalence.⁴⁸

At the level of demographic and environmental characteristics of the local communities, we found that rice farming, which has been shown to be a determinant of schistosomiasis,^{22,26,49} is widely practiced and thus may represent a major source of exposure in the study area. The importance of contact with cercariae-infested water through washing and bathing, combined with widespread open defecation, is acknowledged for governing the transmission of intestinal schistosomiasis.^{38,39,50–52} Among our study population, open surface water was predominantly used for washing and bathing. Moreover, while basic sanitation facilities (i.e., traditional pit latrines) were reported to exist in most of the communities (84%), open defecation was very common. Indeed, open defecation was practiced in all settlements, which might be a main reason for the fecal contamination of freshwater bodies.

What warrants close attention over the course of the interventions, however, is the access to (unexpired), and use of, praziquantel and ACTs in the health facilities of the study communities and a potential change in the socioeconomic status, and proportion of people using improved sanitation. For sustainable control of schistosomiasis, it is crucial to not only regularly treat school-aged children with praziquantel, but also promote latrine construction and use, coupled with hygiene education and behavior change efforts,⁵³ and to make praziquantel available at all health centers so that those in need can get treatment. Our data showed that the proportions of first graders (mean age: 6.5 years) with heavy infection were higher than among 9- to 12-year-old children (mean age: 10.5 years). This observation might indicate an upsurge in transmission over the last few years.

Our findings show that prevalence estimates differ considerably, which is also influenced by age, sex, and sampling efforts and which needs to be taken into account when planning schistosomiasis control and elimination. The baseline characteristics presented here at the onset of a multi-year SCORE study provide important information for the years to come in this cluster-randomized intervention trial, which will help to determine the best strategies to sustainably control schistosomiasis *mansoni* in moderate endemicity areas. In addition, the results of this survey represent an extensive evidence-base for the extent of intestinal schistosomiasis and potential transmission sources to be addressed by the ongoing national schistosomiasis (and soil-transmitted helminthiasis) control program in Côte d'Ivoire.

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Authors' addresses: Rufin K. Assaré, Swiss Tropical and Public Health Institute, and University of Basel, Basel, Switzerland, Unité de Formation et de Recherche Biosciences, Université Félix Houphouët-Boigny, and Département Environnement et Santé, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire, E-mail: hrufinass@yahoo.fr. Eveline Hürlimann, Swiss Tropical and Public Health Institute, and University of Basel, Basel, Switzerland, and Département Environnement et Santé, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire, E-mail: eveline.huerlimann@unibas.ch. Mamadou Ouattara, Nicaise A. N'Guessan, Yves-Nathan T. Tian-Bi, Ahoua Yapi, and Patrick K. Yao, Unité de Formation et de Recherche Biosciences, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire, E-mails: mamadou_ouatt@yahoo.fr, nicaisayan@yahoo.fr, tianbyth@yahoo.fr, yapih@yahoo.fr, and ykpatrick@yahoo.fr. Jean T. Coulbaly, Swiss Tropical and Public Health Institute, and University of Basel, Basel, Switzerland, and Unité de Formation et de Recherche, Université Félix Houphouët-Boigny, and Département Environnement et Santé, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire, E-mail: couljeanvae@yahoo.fr. Stefanie Knopp, Swiss Tropical and Public Health Institute, and University of Basel, Basel, Switzerland, and Department of Life Sciences, Natural History Museum, London, United Kingdom, E-mail: s.knopp@unibas.ch. Eliézer K. N'Goran, Unité de Formation et de Recherche Biosciences, Université Félix Houphouët-Boigny, and Département Environnement et Santé, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire, E-mail: eliezerngoran@yahoo.fr. Jürg Utzinger, Swiss Tropical and Public Health Institute and University of Basel, Basel, Switzerland, E-mail: juerg.utzinger@unibas.ch.

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