Risk factors and ultrasound aspects associated with Urogenital Schistosomiasis among primary school children in Mali (West Africa)

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Research Article

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Abstract

Background: Urogenital schistosomiasis is endemic in Mali and a major cause of morbidity in large parts of the world. It is of great socioeconomic and public health importance and has important consequences. The aim of our work was to study the risk factors and ultrasound aspects associated with urogenital schistosomiasis.

Methods: We conducted a cross-sectional study in November 2021 with 971 children aged 6 to 14 years randomly recruited in six schools in three districts in the Kayes region. Demographic, socioeconomic and clinical data were collected. Hematuria was systematically searched by strips and *Schistosoma haematobium* eggs in urine detected by the filtration method. The urinary tract was examined by ultrasound. Associations between each of these variables and disease infection were analyzed using multivariate logistic regression.

Results: The overall prevalence was 50.2% with an average intensity of 36 eggs (1 to 1020 eggs)/10mL of urine. Urogenital schistosomiasis infection did not vary according to sex or age group. There is no correlation between risk factors and the urogenital schistosomiasis infection. Hematuria was strongly associated with urogenital schistosomiasis infection (p<0.0001). Among the 240 children who participated to the ultrasound examinations, focal lesion on bladder was observed, while ultrasound findings of the urethra and kidneys revealed a very low rate of dilatation.

Conclusion: This work shows that parasitological findings and ultrasound signs, especially bladder lesions, were strongly associated with urinary schistosomiasis (p<0.0001). Despite of mass drug administration based on Praziquantel urogenital schistosomiasis infection is still endemic in the study site.

Background

Schistosomiasis is a neglected tropical disease (NTD) caused by a dioecious blood fluke of the genus *Schistosoma* (1). Human schistosomiasis is the most widespread waterborne parasitic infections in the world that produces serious consequences for economy and public health (2, 3). It is estimated that nearly 700 million people live in areas where the disease is endemic (4) and approximately 236.6 million people needed preventive treatment in 2019 in 78 countries (5, 6). Sub-Saharan Africa accounts for 90% of infected cases (7).

In Mali, epidemiological surveys on schistosomiasis conducted by the National Schistosomiasis Control Program have shown that the entire country is affected (8–10). The urogenital schistosomiasis caused by *Schistosoma haematobium* is more prevalent than intestinal schistosomiasis caused by *S. mansoni* (10) ; the “Office du Niger” region is the only area where both species are co-endemic (8). Due to their transmission routes these diseases occur around dams, small reservoirs, ponds and rivers. Rural and suburban communities are more exposed to the parasite than the urban communities (11, 12). At individual level, since schistosomiasis is transmitted through contact with contaminated freshwater, anthropogenic factors are important to fully understand the transmission of the pathogen. These anthropogenic factors are usually assessed through questionnaire referencing both socioeconomic and sociodemographic parameters (13, 14).

According to WHO recommendations, ultrasound is an excellent method for obtaining information concerning the changes that occur on the internal organs after schistosomiasis infection (15). The prevalence and severity of pathological changes detected by ultrasound correlate with the intensity of infection, as measured by the frequency and quantity of eggs excreted in the urine (15). In urogenital schistosomiasis, the adult worms reside in the venous plexus of the urinary bladder and morbidity is caused by egg deposition around the urinary tract. The pathology is mainly found in the urinary bladder, ureters, and kidney (2). The most common lesions are irregularities of the bladder wall, a distorted bladder shape, and wall thickening; bladder masses may be also present (15). Lesions in the upper urinary tract, such as ureter dilatation and hydronephrosis, are less frequent but usually more severe, indicating a higher level of pathology (16, 17).

The present study proposes to analyze both risk factors and ultrasound aspects associated with urogenital schistosomiasis in 6 transmission sites of the Kayes province in Mali. First, a parasitological study accompanied by a sociological survey allowed us to measure the prevalence of the disease and to infer the anthropological factors that could explain the cases of contamination. Second, we measured the morbidity factors on a cohort of patients using ultrasonography.

Methods

Study population and data collection

The study took place in six villages endemic for *S. haematobium* in the Kayes region, western Mali (18) and concerned 3 sanitary districts: Kayes, Bafoulabé and Diema (Fig. 1). The distances between the districts ranged from 20 to 286 km. The studied villages were chosen according to their proximity to water points (ponds for Diéma, Senegal River and its tributaries for Kayes and Bafoulabé).

Agriculture and livestock breeding are the two main economic activities of the population (19). Two districts (Bafoulabe and Kayes) belong to the North-Soudanian climatic zone with two major seasons: the wet season from May-June to October and the dry season from November to April-May. The mean annual rainfall is up to 1.000mm, which occurs mainly during the period from July to September. Diéma, located further north of the country, has a Sahelian climate with also two seasons: a wet season from July to September-October and a dry season that covers the rest of the year. The annual rainfall is about 600 to 800mm (19). Two villages near the water points were selected in each district: Diakalèl and Koussané in Kayes; Babaroto and Sorané in Bafoulabe and Fangouné Bamanan and Débo Massassi in Diema district.

Type, period, and study population

The study was an observational cross-sectional study carried out in November 2021. The studied population consisted of 6–14 years old aged children attending grades 3–6 in six primary schools. The minimum sample size was calculated based on the previous urogenital prevalence obtained in each school using the Schwartz formula, considering a 10% refusal rate and sampling errors (NSTCP, report 2015).

Data Collection

Anthropogenic factors

A total of 971 children were sampled (Table 1). Children were randomly selected from the list of children in each class until the required number of the sample was reached. We have obtained the minimum sample size except for Fangouné Bamanan. Socioeconomic and sociodemographic information, including village, gender, age, were obtained using a structured questionnaire. Closed-ended questions were used to facilitate the children's response. Multiple data have been recorded: parents' level of education (yes or no), type of toilet (modern or traditional), frequency of use of streams (yes or no), type of water used (drilling, river, rain, drinking), and reason for frequenting streams (swimming, fetching water, taking a bath). The teachers helped us if the child had difficulties to answer. Data were recorded on survey forms with identifiers for each child.

Parasitological examination

All urine samples were collected between 10.00 am and 2.00 pm, (the favorable period for the elimination of schistosome eggs in the urine) by trained laboratory technicians.(6) From each subject, urine was collected in a properly labeled sample container. A filtration technique was used to analyze the samples. A total of 10 mL of urine was taken from each sample container after mixing it. The mixed sample was filtered through a Whatman filter (CAT N° 1001-025, 25 mm) which was stained with a 3% ninhydrin solution. After drying, the filters were immersed into water and then examined under a microscope for characteristics of terminal spurred schistosome eggs (20). The prevalence rate of schistosomiasis in the schools was defined as the number of positive individuals per total number of individuals examined per school. *S. haematobium* intensity was classified into three categories: i) no egg; ii) light infection (1–49 eggs per 10 mL of urine); and iii) heavy infection (≥ 50 eggs per 10 mL of urine).

Clinical examination and ultrasonography

Clinical signs (abdominal pain, pollakiuria and dysuria) were collected through questioning and physical examination by a general practitioner. Microscopic hematuria was determined using Hemastix test strips (Medi-Test Combi 2). Ultrasound evaluations were carried out by a specialist with a portable ultrasound device (Digital Ultrasonic Diagnostic Imaging System – Mindray, 15" LCD display with tilt angle for better visualization). All examinations were carried out by the same specialist at all sites. The sample size of children screened by ultrasound was 240 (40 children per school). Children were asked to drink plenty of water before the ultrasound examination, which took place only when the bladder was full. In accordance with current WHO guidelines (15), the following features of the bladder were recorded: the shape (normal vs anormal), the wall irregularity (no lesion, focal lesion or diffuse lesion), the wall thickness (no lesion, focal lesion or diffuse lesion), the mass presence (no mass, simple mass or multiple mass) and the polyp presence (no polyp, simple polyp or multiple polyp). We also measured the degree of dilatation of the urethra (no dilated, dilated or strongly dilated) and the kidney (no dilated, dilated or strongly dilated). Any marked abnormalities in the bladder, ureter and especially the renal pelvis, systematically prompted the resumption of ultrasound after urination to exclude the possibility of dilatation due to bladder and ureteral repletion.

The exact characterization of pathological changes was calculated using the global score as an index of the severity of morbidity and lesion defined by WHO (15). This score classifies the probability of urogenital schistosomiasis infection as unlikely, probable or very likely.

Statistical analysis

The data was entered in using Excel software. Calculations of prevalence and intensity of infection were made using SPSS v 23.0 (IBM). All variables were categorical including the age of the participants divided into two age groups (6–10 and 11–14 years). Multivariate logistic regressions were used to infer the link between categorical variables and prevalence or intensity of urogenital schistosomiasis infection. P values below 0.05 were considered as significant.

Results

Risk factors associated to urogenital schistosomiasis infection

A total of 971 children participated in the study (Table 1). The highest enrolment was from Diakalèl (n = 251) and the smallest from Babaroto (n = 86). Boys (597/971–61.5%) were most frequent than girls (374/971 – 38.5%). The age group of children aged 6–11 years was the most common (494/971–50.88%).

Prevalence and intensity of urogenital schistosomiasis infections according to sociodemographic factors are presented in Table 1. The overall prevalence was 50.2% with an average intensity of 36 eggs/10 mL of urine and the number of eggs varied from 1 to 1020. Infection prevalence varied significantly according to the site and ranges from 29.1% in Babaroto to 78.1% in Diakalel (*$p < 0.0001$*). Three clusters of sites can be identified. Baboroto and Débo Massassi showed both the lowest prevalence and the lowest infection intensity, Fangouné Bamanan, Koussané and Saorané were intermediate, and the highest prevalence and intensity were observed in Diakalel. The gender or age group did not significantly affect the prevalence or intensity of infection ($p > 0.05$).

Table 1
Multivariate logistic analyses of socio-demographic factors associated with urogenital schistosomiasis infection in Kayes region (Mali). In parentheses the percentage according to the number of samples.

		Prevalence		***Intensity***			
Socio-demographic variables	**Number of samples**	**Number of Positive**	**p-value**	**No**	**Light**	**Heavy**	**p-value**
Sites (minimal sample size)			*< 0.0001*				*< 0.0001*
Baboroto (89)	86	25(29.1)		61(70.9)	21(24.4)	4(4.7)	
Débo Massassi (224)	224	67(29.9)		157(70.1)	58(25.9)	9(4.0)	
Diakalel (251)	251	196(78.1)		55(21.9)	148(59.0)	48(19.1)	
Fangouné Bamanan (255)	142	76(53.5)		66(46.5)	61(43.0)	15(10.6)	
Koussané (138)	138	67(48.6)		71(51.4)	56(40.6)	11(8.0)	
Saorané (130)	130	57(43.8)		73(56.2)	52(40.0)	5(3.8)	
Sex			*0.13*				*0.86*
Girls	374	197(52.7)		177(47.3)	152(40.6)	45(12.0)	
Boys	597	291(48.7)		306(51.3)	244(40.9)	47(7.9)	
Age group (years)			*0.13*				*0.58*
[6–11[	494	239(48.4)		255(51.6)	185(37.4)	54(10.9)	
[11–15[	477	249(52.2)		228(47.8)	211(44.2)	38(8.0)	

Table 2 shows the influence of socio-economic factors on prevalence and intensity of urogenital schistosomiasis infections in Kayes region, Mali. The type of toilet does not influence the prevalence of infection ($p = 0.083$). Surprisingly, the intensity of infection seems to be favored by using modern toilet ($p = 0.008$). This might be due to a sampling bias and the very low number of children using modern toilets ($n = 4$). Children with washing habit at the river showed the highest prevalence and intensity of infection ($p < 0.0001$) similarly to children using borehole or potable water ($p < 0.0001$). Elimination of urine in the water positively influences the prevalence ($p = 0.028$) but not the intensity of infection ($p = 0.10$). Parent activities slightly influence the prevalence with trader and fishermen's children being the most infected ($p = 0.032$). Finally, prevalence and intensity of infection were not influenced by the frequentation of river or the distance from the house to the water source ($p > 0.05$).

Table 2
Multivariate logistic analyses of socio-economic factors associated with urogenital schistosomiasis infection in Kayes region (Mali).

		Prevalence		*Intensity*			
	Number of samples	**Number of Positive**	**p-value**	**No**	**Light**	**Heavy**	**p-value**
Socio-economic factors		n (%)		n (%)	n (%)	n (%)	
Type of toilet			*0.083*				*0.008*
Modern	4	4(100.0)		0	3(75.0)	1(25.0)	
Traditionnel	967	483(50.0)		483(50.0)	393(40.7)	90(9.3)	
Frequentation of the River			*0.41*				*0.24*
No	18	10(55.6)		8(44.4)	10(55.6)	0	
Yes	953	478(50.2)		475(49.8)	386(40.5)	92(9.7)	
Activity conducted at the river			*< 0.0001*				*< 0.0001*
Swim	784	348(44.5)		435(55.5)	288(36.7)	61(7.8)	
Search for water	18	11(61.1)		7(38.9)	10(55.6)	1(5.6)	
Wash	151	118(78.1)		33(21.9)	88(58.3)	30(19.9)	
Home water source supply			*< 0.0001*				*< 0.0001*
River	487	175(35.9)		312(64.1)	151(31.0)	24(4.9)	
Bore-hole	96	71(74.0)		25(26.0)	56(58.3)	15(15.6)	
Rain	170	93(54.7)		77(45.3)	75(44.1)	18(10.6)	
Potable	218	149(68.3)		69(31.7)	114(52.3)	35(16.1)	
Distance from the house of the water source			*0.54*				*0.12*
Away	54	27(50.0)		27(50.0)	26(48.1)	1(1.9)	
Near	917	461(50.3)		456(49.7)	370(40.3)	91(9.9)	
Elimination of urine in water			*0.028*				*0.10*
No	73	45(61.6)		28(38.4)	38(52.1)	7(9.6)	
Yes	898	443(49.3)		455(50.7)	358(39.9)	85(9.5)	
Parent activity			*0.032*				*0.14*
Farmer	282	122(43.3)		160(56.7)	103(36.5)	19(6.7)	
Trader	69	42(60.9)		27(39.1)	33(47.8)	9(13.0)	
Official	37	17(45.9)		20(54.1)	14(37.8)	3(8.1)	
Fisherman	26	15(57.7)		11(42.3)	13(50.0)	2(7.7)	

Clinical Signs And Ultrasonography

The analyses of clinical signs are presented in Table 3. Except for hematuria, no significant difference in clinical signs was observed between infected and uninfected patients ($p > 0.05$). Indeed, infected patients had higher frequency of hematuria compared to uninfected. Among infected patients, hematuria is mainly observed for light infection (47.8%).

Table 3
Clinical signs associated with urogenital schistosomiasis infection in Kayes region

Clinical signs		*Prevalence*		*Intensity*			
	Number of samples	**Number of Positive**	**p-value**	No	Light	Heavy	**p-value**
Abdominal pain			> 0.05				0.18
No	523	270 (51.6)		253 (48.4)	226 (43.2)	44(8.4)	
Yes	448	218 (48.7)		230 (51.3)	170(37.9)	48 (10.7)	
Pollakiuria			> 0.05				0.068
No	447	242 (54.1)		205 (45.9)	199 (44.5)	43 (9.6)	
Yes	524	246 (46.9)		278 (53.1)	197 (37.6)	49 (9.4)	
Dysuria			> 0.05				0.27
No	586	286(48.8)		300 (51.2)	237 (40.4)	49(8.4)	
Yes	385	202 (52.5)		183 (47.5)	159 (41.3)	43 (11.2)	
Hematuria			p < 0.0001				p < 0.0001
No	881	412(46.8)		469 (53.2)	353 (40.1)	59 (6.7)	
Yes	90	76 (84.4)		14 (15.6)	43 (47.8)	33 (36.7)	

Table 4 shows the different features recorded on the bladder using ultrasonography. Among the 240 children recruited for ultrasound examinations, anormal bladder shape was reported in only one male in the Saorané site. Only focal lesion on bladder irregularity was observed. These focal lesions were lower in Diakalèl compared to the other sites. Both focal and diffuse lesions were observed on the bladder thickness. These lesions are relatively balanced according to the sites with the highest frequency of focal lesion in Koussané and the highest frequency of diffuse lesion in Débo Massassi and Diakalel. The lowest frequency of diffuse lesion was observed in Baboroto. No mass or polyps were recorded in Baboroto, Koussané and Saorané but very few were recorded on the other sites. The probability scores were the lowest in Baboroto, Koussané and Saorané. Very likely scores were only observed on Diakalel, Débo Massassi and Fangouné Bamanan. Finally, with regards to the sex or the age of the children, no difference was observed ($p > 0.05$).

Table 4
Distribution of ultrasound parameters of the bladder according to sites, sex and age

		Shape			**Wall irregularities**			**Wall Thickness**			**Mass**		
	Number of samples	**Normal**	**Anormal**	**p-value**	**Focal**	**Diffuse**	**p-value**	**Focal**	**Diffuse**	**p-value**	**Simple**	**Multiple**	**p-value**
Site				0.41			< 0.0001			< 0.001			0.015
Baboroto	39	39(100.0)	0		35(89.7)	0		9(23.1)	7(17.9)		0	0	
Débo Massassi	40	40(100.0)	0		32(80.0)	0		16(40.0)	15(37.5)		2(5.0)	3(7.5)	
Diakalèl	41	41(100.0)	0		23(56.1)	0		7(17.1)	15(36.6)		0	2(4.9)	
Fangouné Bamanan	40	40(100.0)	0		36(90.0)	0		13(12.5)	22(32.5)		2(5.0)	5(12.5)	
Koussané	40	40(16.7)	0		37(92.5)	0		8(60.0)	8(20.0)		0	0	
Saorané	40	39(100.0)	1(2.5)		30(75.0)	0		11(40.0)	13(27.5)		0	0	
Sex				0.59			0.15			0.35			0.60
Female	99	99(100.0)	0		76(76.8)	0		22(22.2)	33(33.3)		1(1.0)	3(3.0)	
Male	141	140(99.3)	1(0.7)		117(83.0)	0		42(29.8)	47(33.3)		3(2.1)	7(5.0)	
Age (years)				0.67			0.51			0.66			0.095
[6–11[	80	80(100.0)	0		64(80.0)	0		21(26.3)	24(30.0)		0	1(1.3)	
[11–15[	160	159(99.4)	1(0.6)		129(80.6)	0		43(26.9)	56(35.0)		4(2.5)	9(5.6)	

Ultrasound findings of the urethra and kidneys revealed a low rate of dilatation (Table 5). Three cases of proximal and distal dilated urethra were recorded in Débo Massassi and Diakalèl. No abnormalities were observed on the kidneys.

Table 5
Distribution of ultrasound parameters of the urethra and kidneys according to sites, sex and age.

			Urethra		**Kidney**
	Number of samples	Dilated	Strongly dilated	**p-value**	No dilated
Site				*0.54*	
Baboroto	39	0	0		39(100.0)
Débo Massassi	40	1(2.5)	0		40(100.0)
Diakalèl	41	1(2.4)	1(2.4)		41(100.0)
Fangouné Bamanan	40	0	0		40(100.0)
Koussané	40	0	0		40(100.0)
Saorané	40	0	0		40(100.0)
Sex				*0.16*	
Female	99	2(2.0)	0		99(100.0)
Male	141	0	1(0.7)		141(100.0)
Age (years)				*0.46*	
[6–11[	80	0	0		80(100.0)
[11–15[	160	2(1.3)	1(0.6)		160(100.0)

Multivariate analysis between ultrasound signs and parasitological findings showed that bladder wall irregularity and thickness were strongly associated with the prevalence and intensity of urogenital schistosomiasis infection (Table 6). Children with diffuse lesion in wall irregularity and focal lesion in wall thickening were frequently positive for urogenital schistosomiasis infection with (78.2%) and (85%), respectively. However, carriers with high intensity also had irregular bladder with focal lesions (18.1%) and thickening with diffuse lesions (27.5%) ($p < 0.0001$). Children with a high probability of having urogenital schistosomiasis infection were predominantly positive (90.9%) with a high load (27.3%). No significant variation was noted in shape, mass, polyp and urethra. (Table 6).

Table 6
Distribution of ultrasound parameters of the bladder according to urogenital schistosomiasis prevalence and intensity.

		Prevalence		**Intensity**			
	Number of samples	Positive	p-value	No	light	heavy	p-value
Shape			*0.68*				*0.63*
Normal	239(99.3)	162(67.8)		77(32.2)	124(51.9)	38(15.9)	
Anormal	1(0.7)	1(100.0)		0	1(100.0)	0	
Wall irregularity			*< 0.0001*				*< 0.0001*
Normal	47(19.6)	12(25.5)		35(74.5)	9(19.1)	3(6.4)	
Focal lesion	193(80.4)	151(78.2)		42(21.8)	116(60.1)	35(18.1)	
Diffuse lesion	0	0		0	0	0	
Wall hickness			*< 0.0001*				*< 0.0001*
Normal	96(40.0)	40(41.7)		56(58.3	34(35.4)	6(6.3)	
Local	0	0		0	0	0	
Diffuse	80(33.3)	68(85.0)		12(15.0)	46(57.5)	22(27.5)	
Mass			*0.11*				*0.28*
Normal	226 (94,1)	150 (92,6)		76 (98,7)	116 (92,8)	34 (89,5)	
Simple	4(1.7)	4 (100.0)		0	3(75.0)	1(25.0)	
Multiple	10(4.2)	9(90.0)		1(10.0)	6(60.0)	3(30.0)	
Polyp			*0.38*				*0.41*
Normal	236 (98,4)	158 (97,5)		77 (100)	122 (97,6)	37 (97,4)	
Simple	2(0.8)	2(100.0)		0	2(100.0)	0	
Multiple	2(0.8)	2(100.0)		0	1(50.0)	1(50.0)	
Score			*< 0.0001*				*< 0.0001*
Unlikely	102(42.5)	46(45.1)		56(54.9)	39(38.2)	7(6.9)	
Probable	127(52.9)	107(84.3)		20(15.7)	79(62.2)	28(22.0)	
Very likely	11(4.6)	10(90.9)		1(9.1)	7(63.6)	3(27.3)	
Urethra			*0.48*				*0.13*
No dilated	237(98.8)	160(67.5)		77(32.5)	123(51.9)	37(15.6)	
Dilated	2(0.8)	2(100.0)		0	2(100.0)	0	
Roughly dilated	1(0.4)	1(100.0)		0	0	1(100.0)	

Discussion

The results of Our study demonstrated an average prevalence of 50.1% of urogenital schistosomiasis infection in Kayes region, Mali. This prevalence is higher than that previously reported 26.8% in the same region (21). In our study, the sex of the patient did not influence the prevalence of infection. The influence of the host sex on urogenital schistosomiasis infection shows contrasting results with previously reported data. Female was observed to be more infected compare to male in Bandanyenje region (Zimbabwe) (22), the opposite was observed in Oromia regions (Ethiopia) (23) and no difference was observed in Kayes region (Mali) (21) or in South Nigeria (13). The effect of patient's sex on schistosome prevalence was recently reviewed and statistically analyzed using meta-analytical approach (24). This revealed that males were significantly more affected than female. This last difference is more explain by behavioral compared to immunological differences. Gender difference in water activities, cultural or religious beliefs, professional activities, or social roles can explain a difference in water contact frequency and as a consequence a difference in the prevalence between male and female. The absence of difference we observed in our study could be explained by the fact that in rural zones of Mali both sexes have water contact activities for either domestic or recreational use. We did not observe a difference in either prevalence or intensity of urogenital schistosomiasis infection according to age [6–11[vs [11–15[years old. This is consistent with findings previously reported in Mali or Ivory coast (11, 14). Like for the gender, the influence of the age of the patient presented contrasting results on infection prevalence. Indeed, several studies have shown that older patients are more infected than younger ones (23, 25, 26), what our study could not confirm. Authors proposed that older children have more recreational activities than younger ones (27).

Our study has shown that some socioeconomic parameters could influence the risk of urogenital schistosomiasis infection. Washing at river, having bore-hole or potable water source supply, and having trader or fishermen parents positively influence the prevalence or intensity of infection, which is unexpected considering the schistosome transmission route. Parent fishermen activity is the only factor expected to have a positive influence on transmission, this has been observed in previous studies in Tanzania, Nigeria, and Zimbabwe (28–30). Socio-economic surveys are difficult to assess as children's responses can be influenced by several parameters such as distraction, stress of the interviewer, their neighbor's response, getting rid of the interviewer quickly, or misunderstanding of the question.

Analysis of children's clinical signs with urogenital schistosomiasis infection showed that the infection probability doubled when children harbor hematuria. Hematuria is a well-founded symptom to detect schistosomiasis infection (31, 32), however it remains a poor diagnostic tool considering that 46.8% positive children do not present hematuria.

Ultrasound examination makes possible to assess the pathology of the urinary tract in urogenital schistosomiasis infection, provides a more accurate assessment of internal damage than by parasitological determination of eggs or urinalysis. In addition, it is an effective method for assessing the course of damage, as it is safe and more effective especially when combined with parasitological examinations. Although it is less used in large areas of sub-Saharan Africa where the disease is endemic, it remains a standard tool in the management of schistosomiasis. Few studies have used ultrasound to study morbidity associated with urinary schistosomiasis, mainly because of its cost. Bladder ultrasonography showed that most children with irregularity focal lesion and thickening diffuse lesion were positive for urogenital schistosomiasis infection with (78.2%) and (85%) respectively. However, some studies did not show a significant link between the status of infection (i.e. positive to urogenital schistosomiasis infection) and the bladder lesions. Previously, only 2.9% and 26.6% of infected patients were shown to have bladder lesion in plateau Dogon and Molodo in Mali, respectively(9, 33). These contrasting results may be associated to i) the absence of specificity of the ultrasonography ii) the fact that complications appear only after several years of infection iii) the treatment, which reduces the rate of complication. On the other hand, the ability of ultrasound to demonstrate lesions that are highly specific to urogenital schistosomiasis infection is subject to conflicting opinions(34, 35). The low morbidity observed is believed to be due to the fact that complications appear only after several years of infection. The various treatment campaigns over the last 10 years with praziquantel by the National Program to combat Schistosomiasis and Helminths) reduced the rate of complications. The strong association between parasite load and morbidity reinforces the idea of conducting additional studies in terms of morbidity.

Conclusion

Our results show that urogenital schistosomiasis infection was still endemic in many regions of Mali despite decades of mass treatment with praziquantel. However, the low rate observed in some localities (e.g. Babaroto) might probably reflect an impact of treatment on infection. This work shows that hematuria was strongly associated with urogenital schistosomiasis infection and parasitological findings and ultrasound signs, especially bladder lesions correlated with urinary schistosomiasis. The high percentage of signs associated with high loads reinforces the idea that further studies in terms of schistosomiasis-related morbidity are still needed.

Abbreviations

EC
Ethical committee
FMOS
Faculty of Medicine and Dentistry
IBM
International Business Machine
LCD
Liquid crystal control
NSTCP
National Schistosomiasis and Soil-transmitted helminths control program (NSTCP):NTD:Neglected Tropical Diseases
PZQ
Praziquantel
SPSS
Statistical Package for Social Sciences
STH
Soil-transmitted helminths
WHO
World health Organization.

Declarations

Ethical approval and consent to participate

The proposal was reviewed and approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Pharmacy and Dentistry, University of Bamako (Ref 2018/71/CE/FMPOS). Community consent was obtained before starting the study. The parent or guardian of each study participant signed a consent form. At the end of the study, all the positive children were treated with PZQ (40 mg/kg body weight) according to the schistosomiasis and Soil-transmitted helminths Control Program strategy in Mali (NSTCP).(21)

Competing interests

The authors declare that they have no competing interests

Consent for publication

No applicable

Availability of data and materials

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

PA, SDN, JB, MI and AD participated in the design of the study updated the research methodology and contributed to the drafting of the final document. They also contributed in the writing of the manuscript, assured the coordination of the trial and reviewed the manuscript for submission.

PA, ATD, HG, BAA. participated in the design of this study and in on-site execution by collecting and analyzing data.

PA. and DA performed the statistical analysis.

SDN and BS collected and analyzed clinical and ultrasound data.

AD, SDN, MI and JB reviewed the final version.

All authors read and approved the final manuscript.

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Figures

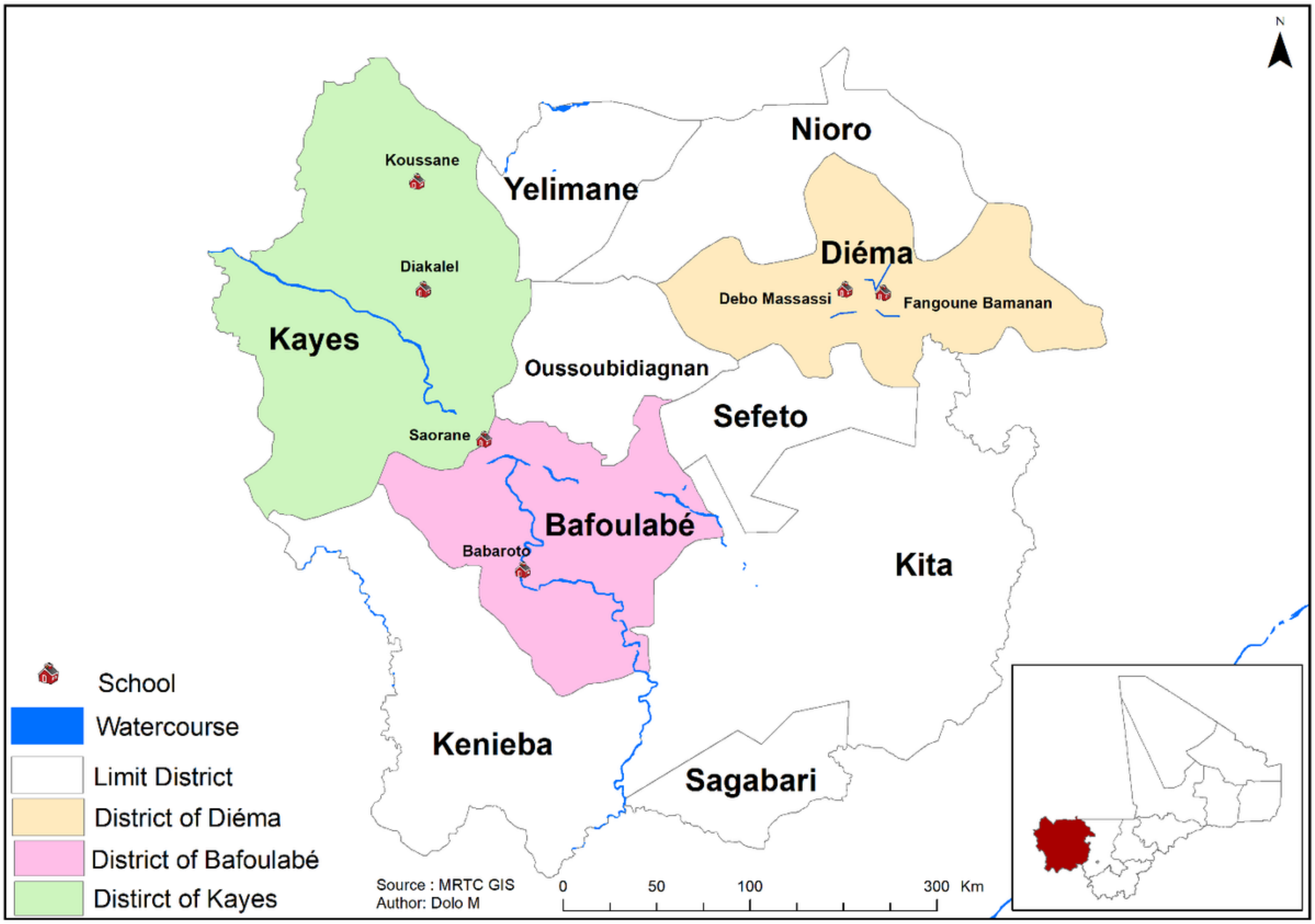

Figure 1

Map of the study' districts in Kayes region (Mali, West Africa)