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Original Article

Schistosomiasis among pregnant women in Njombe-Penja health district, Cameroon

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Abstract

Introduction: Schistosomiasis is a neglected tropical disease with endemic foci in Cameroon. Epidemiological data on schistosomiasis in pregnancy are scarce in the country. This study describes the prevalence, diversity and factors associated with schistosomiasis in pregnant women in Njombe-Penja where schistosomiasis was first reported in 1968.

Methodology: Two hundred and eighty-two (282) pregnant women were enrolled at first antenatal consultation between April and December 2016. A questionnaire was used to document socio-economic and obstetric information. Stool and terminal urine samples were collected and analysed using Kato-Katz/Formol-Ether concentration techniques and centrifugation methods respectively. Haemoglobin concentration was measured from finger prick blood, using an URIT®-12 electronic haemoglobinometer. Bivariate and logistic regression were used for statistical analyses with Epi-Info version 7.2.1.0. Statistical significance level was set at 0.05.

Results: The overall prevalence of schistosomiasis was 31.91%. *Schistosoma guineensis*, *S. haematobium* and *S. mansoni* infections were found in 0.35% (n = 1), 4.96% (n = 14) and 28.01% (n = 79) of participants, respectively. Co-infection with two species of *Schistosoma* was found in 4.44% of these women. The prevalence of this disease was significantly higher in younger women (≤ 20 years old) and among residents of Njombe. All *S. haematobium* infected women were anemic and infection was associated with significantly lower haemoglobin levels (p = 0.02).

Conclusion: The prevalence of schistosomiasis is high among pregnant women in Njombe-Penja, with some adverse effects on blood levels. Three *Schistosoma* species were found. Female of childbearing age should be considered for mass drug administration.

Key words: Schistosomiasis; pregnancy; *Scistosoma*; anaemia; Njombe, Penja.

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Introduction

Schistosomiasis, also known as bilharzia, is an acute and chronic neglected tropical disease (NTD) caused by parasitic flatworms belonging to the genus *Schistosoma*. Schistosomiasis affects an overall 240 million individuals across 74 countries and territories worldwide, including 40 million women of childbearing age, mostly the underprivileged [1-2]. Sub-Saharan Africa accounts for 70% of cases, most regions and islands being affected, except for Kalahari Desert and the extreme southern region of the continent [3-4]. Human are affected by six species, namely *Schistosoma haematobium* that lives within the perivesicular venules, *Schistosoma mansoni*, *Schistosoma guineensis, Schistosoma intercalatum*, *Schistosoma japonicum* and *Schistosoma mekongi*, which live within the mesenteric venules. In Africa, schistosomiasis is mostly caused by *S. haematobium* and *S. mansoni* [5,6].

In a survey carried-out in 1999, it was estimated that 106,6000 persons were infected with *S. haematobium* in Cameroon, with a national prevalence of 6.1%. Overall, 713,000 persons were infected with *Schistosoma mansoni*, with a national prevalence of 4.5%, ten thousands new cases being recorded each year [7-9]. Endemic foci of *S. haematobium, S.*

guineensis and *S. mansoni* are mostly found in the northern region of the country and the South-West region. In addition, there are spotted foci including the Moungo Division in the Littoral region [9-12].

Huge efforts have been made since 2004 to fight against schistosomiasis and other NTDs in Cameroon. National and international commitment is perceptible through sensitization, mass drug administration and water and sanitation activities by dedicated research institutions and the national control programme. As of 2007, national integrated deworming campaigns and praziquantel distribution have been implemented yearly in endemic areas [9,12]. However, mass drug administration (MDA) of praziquantel against schistosomiasis has to-date targeted only children from 1 to14 years old. Adults including pregnant women are not generally considered for treatment, though there are evidences of increased vulnerability to infections during pregnancy. Moreover, the availability of praziquantel within the health system remains low [13-15].

Epidemiological data on schistosomiasis during pregnancy are scarce in sub-Saharan Africa as most of studies are focused on schoolchildren [16]. In Cameroon, few studies on maternal schistosomiasis have been reported [17-20]. Thus, it is difficult to have a reliable estimate of the extent of the infection in this stratum of the population. Furthermore, being left untreated during control interventions, pregnant women could face adverse pregnancy outcome and serve as reservoirs of transmission, therefore jeopardizing control efforts over time.

Prevalence, diversity of *Schistosoma* infection, factors associated with the disease and association with blood levels in pregnant women were assessed in this study.

Methodology

Ethical considerations

Ethical clearance was obtained from the University of Douala Institutional Review Board (CEI-DU/153/02/2015/T). Administrative clearance was issued by the Regional Delegation of Public Health for the Littoral region (593/L/MINSANTE/DRSPL/ BCASS). Pregnant women were recruited during their visit to the health facility. The objectives of the study were explained in French, English or Pidgin language depending on which they understood best, and their questions were answered. Written informed consent was obtained from all participants, prior to enrolment. Participants found infected were referred to clinicians of the health centre for adequate care. There was no difference in the care provided to pregnant women who accepted to join in the study and those who did not.

Study area and population

The study was conducted in Njombe (Njombe-Penja health district, Moungo Division, Littoral region of Cameroon), a semi-urban area situated at 94 km west of Douala, economic capital city of Cameroon. Coordinates of Njombe ranged from, latitude 4°34'50" N and longitude 9°39'52" E with an altitude of 99 m above sea level. The study area experiences a tropical climate type with a long rainy season and a short dry season. Average temperature is 26.6 °C and averages rainfall is 3002 mm annually. This is a farming area, with food crops and fruit farms adjacent to major industrial banana, white pepper and flower farms.

Schistosomiasis was first reported in this area in 1968 [21,22]. Total population of Njombe-Penja health district in 2016 was 47,839 inhabitants, including 1533 pregnant women [23]. The study population consisted of volunteer pregnant women visiting the Njombe I Integrated Health Centre. In this area, Payne *et al.* and Lehman *et al.* reported an overall prevalence of 20.1% for schistosomiasis and 13% for intestinal schistosomiasis in the general population respectively [24,25]. The higher prevalence was used for sample size calculation using the Lorentz formula as follows:

$$n = \frac{z^2 * p(1-p)}{d^2}$$

and the minimum sample size was estimated at 247.

Study design, information and sample collection

This study was a cross-sectional survey carried out from April to December 2016. Pregnant women were enrolled at first antenatal consultation (ANC), prior to any health intervention related to their pregnancy. A structured questionnaire was administered in the language they understood best (French, English or Pidgin), in order to collect socio-economic and obstetric information. Each woman received a labelled stool container for stool sample collection and a labelled graduated plastic urine container in order to provide 30 to 50 mL of urine. All urine samples were collected between 10 a.m. and 2 p.m. to coincide with the peak of excretion of *S. haematobium* eggs. Peripheral blood sample for determination of haemoglobin concentration was collected from middle finger prick.

Laboratory analysis

Measurement of haemoglobin was done with an URIT-12 electronic haemoglobinometer (URIT Medical Electronic Co., Ltd. Guilin, Guangxi, China).

Women with haemoglobin levels lower than 11 g/dL were considered anaemic [26] and refered to clinicians for adequate care.

Urine samples were analysed using the centrifugation method as described by Okanla [27]. Briefly, 10 mL of urine were centrifuged at 1000 rpm for 5 minutes. The supernatant was discarded and a drop of Lugol was added to a drop of the sediment. The sample was examined using a CyScope microscope (Partec GmbH, Münster, Germany). Urinary schistosomiasis status was determined by the detection of *S. haematobium* eggs. Intensity of infection (egg/10 mL) was estimated by multiplying the number of eggs counted in one drop (50 µL) times 200. Mild infection was defined as less than 50 ova per 10 mL urine and severe infection as more than 50 eggs per 10 mL urine [28].

Kato-Katz (KK) and Formol-Ether (FE) techniques were used for stool samples analysis as described by WHO [29]. For the KK technique, each sample was sieved and calibrated using the KK template in order to obtain 41.7 mg of sieved stool. The preparation was examined 24 to 48 hours later for *Schistosoma* eggs. For FE technique, 1g of stool was mixed in 10 mL of 10% buffered formaline. Seven mL of filtered preparation was diluted with 3 mL of ether and centrifuged at 1000 rpm for 5 minutes. The supernatant was then discarded. One drop of the sediment was diluted with a drop of Lugol and the sample was examined. The faecal egg output, expressed as eggs per gram of faeces (epg), was calculated by multiplying the egg count by 24 for KK and 10 for FE. Mild infection was defined as < 100 epg, moderate infection as 101-400 epg and severe infection as > 400 epg [30].

Statistical analysis

From the information collected through the questionnaires, participants were categorised according to their age groups (≤ 20 years and > 20 years), level of education (≤ primary school, ≥ secondary school), marital status (single, married), pregnancy age (≤ 28 weeks and > 28 weeks), monthly income (based on the Interprofessional guaranteed minimum wage or SMIG which is 60 USD; < 120 USD and ≥ 120 USD).

Table 1. Characteristics of the study population.

Characteristics		n (%) or mean ± SD	95% CI or range
Age group	> 20	226 (82.48%)	77.45%-86.79%
	≤ 20	48 (17.52%)	13.21%-22.55%
Mean age (years)		24.83 ± 5.57	14-43
Blood group	O	127 (49.22%)	42.97%-55.50%
	Others (A, B, AB)	131 (50.78%)	44.50%-57.03%
Gravidity	Multigravida	74 (27.01%)	21.84%-32.68%
	Paucigravida	200 (72.99%)	67.32%-78.16%
Pregnancy age	> 28 weeks	37 (14.80%)	10.64-19.82%
	≤ 28 weeks	213 (85.20%)	80.18%-89.36%
Level of education	≤ Primary school	115 (44.40%)	38.25%-50.68%
	≥ Secondary school	144 (55.60%)	49.32%-61.75%
Area of residence	Others	28 (9.93%)	6.70%-14.03%
	Njombe	254 (90.07%)	85.97%-93.30%
Marital status	Married	199 (71.33%)	65.63%-76.56%
	Single	80 (28.67%)	23.44%-34.37%
Class revenue	< 120 USD*	177 (87.62%)	82.27%-91.83%
	≥ 120 USD	25 (12.38%)	8.17%-17.73%
Mean monthly revenue		37921 ± 32800	
Occupation	Trader/Worker	93 (34.19%)	28.57%-40.16%
	Farmer/Housewife	132 (48.53%)	42.45%-54.64%
	Student	47 (17.28%)	12.98%-22.31%
Housing material	Definitive materials	133 (48.6%)	42.32%-54.44%
	Temporary materials	142 (51.64%)	45.56%-57.68%
Toilets	Pit toilets	201 (75.85%)	70.23%-80.88%
	No toilet	12 (4.53%)	2.36%-7.78%
	Modern toilets	52 (19.62%)	15.02%-24.92%
HIV infection	No	277 (98.23%)	95.91%-99.42%
	Yes	5 (1.77%)	0.58%-4.09%

*USD: US Dollars; 1 USD = 604,5 FCFA.

Table 2. Sensitivity of Formol-Ether and Kato-Katz techniques for the detection of *S. mansoni* infection.

		Overall results			Sensitivity (95%CI)	PPV* (95%CI)	NPV$^{\mu}$ (95% CI)
		Negative	Positive	Total			
Formol-Ether	Positive	0	36	36	45.57% (34.46%-57.12%)	100% (87.99%-100%)	82.52% (77.06%-86.94%)
	Negative	203	43	246			
	Total$^{£}$	203	79	282			
Kato-Katz	Positive	0	64	64	81.01% (70.30%-88.64%)	100% (92.95%-100%)	93.12% (88.68%-95.96%)
	Negative	203	15	218			
	Total	203	79	282			

*PPV: Positive predictive value; $^{\mu}$NPV: Negative predictive value; Total$^{£}$: number of infected women.

Table 3. Prevalence of *Schistosoma* species and geometric mean egg densities.

Species	Technique	Frequency	GMED*
Schistosoma guineensis	Formol-Ether	1 (0.35%)	20 ± 0
	Kato-Katz	0 (0.0%)	0
	Overall$^{£}$	**1 (0.35%)**	**20 ± 0**
Schistosoma mansoni	Formol-Ether	36 (12.77%)	52 ± 2
	Kato-Katz	64 (22.70%)	55 ± 2
	Overall	**79 (28.01%)**	**54 ± 2**
Schistosoma haematobium	CM$^{\mu}$	**14 (4.96%)**	**51 ± 2**
Schistosoma spp.		**90 (31.91%)**	

$^{\mu}$CM: Centrifugation Method; *GMED: Geometric Mean Egg density (egg per gram and egg per 10mL); Overall$^{£}$: Total number of infected women found with any of the techniques.

Table 4. Frequency of mono and bi-infections with *Schistosoma* spp.

Type of infection		Number of cases	Frequency (95% CI)
Mono-infection	*S. haematobium*	11	12.22% (6.96%-20.57%)
	S. mansoni	75	83.33% (74.31%-89.63%)
	Total	86	95.56% (89.12%-98.26%)
Bi-infection	*S. guineensis - S. mansoni*	1	1.11% (2.20%-6.03%)
	S. haematobium - S. mansoni	3	3.33% (1.14%-9.35%)
	Total	4	4.44% (1.74%-10.88%)

According to number of pregnancies (gravidity), they were categorized as paucigravida (less than 4 pregnancies) and multigravida (4 pregnancies and more). All data were analysed using Epi Info version 7.2.1.0., 2017 (CDC Atlanta, USA). Geometric mean egg density was calculated for each of the parasite after log transformation of laboratory results. The sensitivity of laboratory techniques used for the detection of intestinal schistosomiasis was calculated through dividing the number of positive cases obtained with this specific technique by the total of positive cases from both techniques. Bivariate and multivariate analyses were performed to assess association between exposure and outcome variables. In bivariate analysis, Chi-square and Fisher's exact probability tests were used to assess differences in proportions. ANOVA was used to assess differences in means and Yates Odds Ratios (OR) were calculated to compare the susceptibility of individuals or groups to different parameters. Backward stepwise binary logistic regression was used for multivariate analysis, including variables with p-value ≤ 0,5 at bivariate analysis [31]. Missing data were not computed. The level of significance was set at p-value< 0.05.

Results

Description of study participants

In total, 282 pregnant women participated in this study, mostly residents of the town of Njombe (90.07%) with mean age of 24.8 ± 5.6 (range: 14–43) years. The mean haemoglobin concentration was 10.0 ± 1.2 (range: 7.2–13.9) g/dL and mean number of pregnancies was 3 ± 2 (range: 1–9). Among the participants, 5 (1.77%) were infected with HIV (Table 1). Most of the participants (48.53%) were farmers or housewives and 87.62% had less than twice the SMIG (Interprofessional guaranteed minimum wage) as monthly revenue for their families.

Diversity, prevalence and intensity of Schistosoma infection

Three species of the *Schistosoma* genus were found, namely *S. guineensis*, *S. haematobium* and *S. mansoni*. Overall, 15 cases of all *S.mansoni* infected participants were missed with the KK technique. However, the KK technique was more sensitive for the detection of *S. mansoni* than the Formol-Ether technique (KK sensitivity: 81.01%; FE sensitivity: 45.57%). Moreover, egg count with KK was higher than with FE (GMED: 55 epg versus 52 epg), although no statistically significant difference was found (H = 12.82, p = 0.17; Mann-Whitney test; Table 2).

Ninety women (31.91%) were found infected with *Schistosoma. S. mansoni* was the most prevalent species (28.01%), followed by *S. haematobium* (4.96%). Only one case of *S. guineensis* infection was detected, with egg count corresponding to mild infection. For *S. haematobium*, 50% of infections were severe whereas for *S. mansoni*, severe, moderate and mild infections were 5.06%, 18.99% and 75.95% respectively (Table 3).

Four cases of bi-infection were found and the sole *S. guineensis* detected was in a woman also infected with *S. mansoni* (Table 4).

Factors associated with schistosomiasis

As shown in Table 5, bivariate analysis revealed a significant association of blood group, level of education and occupation with *S. haematobium* infection. The prevalence of *S. haematobium* infection was 4 fold higher in women of group O compared with other blood groups, and 5 fold higher in more educated women. Students were more affected than other occupational categories. In addition, *S. haematobium* was found exclusively in women living in Njombe. However, none of these factors was significantly associated with *S. haematobium* infection in logistic regression.

Infection with *S. mansoni* was significantly associated with age group and residence area. Women aged 20 or younger were twice as infected as their older counterparts; mean age of infected women was significantly lower than their non-infected counterparts (23.7 years vs 25.3 years; p = 0.04). The prevalence of infection in women living in Njombe was 6 fold higher than in women living in other areas. This was later confirmed in logistic regression (aOR = 2.06, p = 0.03; aOR = 5, p = 0.03 respectively).

Considering all *Schistosoma* species, infection was significantly associated with area of residence. Women living in Njombe were more infected (OR = 6.89; p = 0.006). Also, mean age was significantly low for infected women (23.8 years versus 25.3 years; p = 0.029). This result was confirmed with logistic regression (aOR = 5.96, p = 0.02).

Influence of schistosomiasis on blood levels

The prevalence of anaemia in women infected with *S. haematobium* was 100%. Moreso, mean haemoglobin concentration was lower in infected women (9.26 g/dL versus 10.08g/dL; p = 0.02).

Table 5. Factors associated with Schistosomiasis in the study population.

Caracteristic	Class	*Schistosoma haematobium*			*Schistosoma mansoni*			All *Schistoma* species		
		Infected n(%)	OR (CI 95%)	*p*-value*	Infected n(%)	OR (CI 95%)	*p*-value	Infected n(%)	OR (CI 95%)	*p*-value
Age group	> 20	12 (5.31%)	1.29 (0.28-5.96)	0.99	57 (25.22%)	2.12 (1.11-4.05)	**0.034**	67 (29.65%)	1.85 (0.98-3.49)	0.08
	≤ 20	2 (4.17%)			20 (41.67%)			21 (43.75%)		
Blood group	O	11 (8.40%)	3.79 (1.02-13.92)	**0.032**	41 (31.30%)	1.25 (0.73-2.14)	0.51	49 (37.40%)	1.45 (0.86-2.45)	0.20
	Others (A, B, AB)	3 (2.36%)			34 (26.77%)			37 (29.13%)		
Gravidity	Multigravida	2 (2.70%)	2.29 (0.56-15.42)	0.43	16 (21.62%)	1.55 (0.83-2.92)	0.22	18 (24.32%)	1.64 (0.90-3.00)	0.14
	Paucigravida	12 (6.00%)			60 (30.00%)			69 (34.50%)		
Pregnancy age	> 28 weeks	3 (8.11%)	0.50 (0.13-2.40)	0.55	12 (32.43%)	0.76 (0.36-1.62)	0.61	14 (37.84%)	0.71 (0.34-1.46)	0.45
	≤ 28 weeks	9 (4.23%)			57 (26.76%)			64 (30.05%)		
Level of education	≤ Primary school	2 (1.74%)	4.67 (1.01-21.52)	**0.031**	30 (26.09%)	1.05 (0.60-1.83)	0.97	32 (27.83%)	1.30 (0.76-2.21)	0.41
	≥ Secondary school	11 (7.64%)			39 (27.08%)			48 (33.33%)		
Area of residence	Others	0 (0%)	NA	0.37	2 (7.14%)	5.66 (1.31-24.42)	**0.02**	2 (7.14%)	6.89 (1.60-29.71)	**0.006**
	Njombe	14 (5.51%)			77 (30.31%)			88 (34.65%)		
Marital status	Married	9 (4.52%)	1.41 (0.41-4.34)	0.55	50 (25.13%)	1.52 (0.86-2.67)	0.19	56 (28.14%)	1.70 (0.99-2.93)	0.07
	Single	5 (6.25%)			27 (33.75%)			32 (40.00%)		
Class revenue	< 120 USD	7 (3.95%)	0.47 (0.09-2.42)	0.60	49 (27.68%)	0.82 (0.31-2.19)	0.88	54 (30.51%)	1.07 (0.44-2.63)	1
	≥ 120 USD	2 (8.00%)			6 (24.00%)			8 (32.00%)		
Occupation	Trader/worker	3 (3.23%)	0.19 (0.05-0.77)	**0.017**	31 (33.33%)	1.31 (0.50-2.83)	0.62	32 (34.41%)	0.77 (0.38-1.59)	0.61
	Farmer/housewife	4 (3.03%)	0.18 (0.05-0.64)	**0.008**	31 (23.48%)	0.80 (0.38-1.71)	0.71	35 (26.52%)	0.53 (0.26-1.07)	0.11
	Student	7 (14.89%)	NA		13 (27.66%)			19 (40.43%)		
Housing material	Definitive materials	5 (3.76%)	1.73 (0.56-05.83)	0.49	36 (27.07%)	1.09 (0.64-1.85)	0.84	40 (30.08%)	1.19 (0.71-1.97)	0.59
	Temporary materials	9 (6.34%)			41 (28.87%)			48 (33.80%)		
Toilets	Pit toilets	10 (4.98%)	0.86 (0.23-3.23)	0.99	56 (27.86%)	0.95 (0.49-1.87)	1	63 (31.34%)	0.86 (0.45-1.64)	0.78
	No toilet	1 (8.33%)	1.48 (0.14-15.66)	0.99	4 (33.33%)	1.23 (0.32-4.72	1[f]	5 (41.67%)	1.35 (0.37-4.86)	0.74[f]
	Modern toilets	3 (5.77%)	NA		15 (28.85%)			18 (34.62%)		
HIV infection	No	13 (4.69%)	0.20 (0.02-1.89)	0.23	78 (28.16%)	0.64 (0.07-5.80)	1	88 (31.77%)	1.43 (0.23-8.72)	1[f]
	Yes	1 (20.00%)			1 (20.00%)			2 (40.00%)		
OVERALL		14 (4.96%)			79 (17.94%)			90 (31.91%)		

*Except when specified, all p-values are calculated from corrected (Yates) Chi-2; [f]: p-value from Fisher exact test.

Table 6. Effect of schistosomiasis on the prevalence of Anaemia and haemoglobin concentration.

		Schistosoma infection		Statistics*	*p*-value
		Negative	Positive		
S. haematobium	Anaemia n(%)	189 (76.52%)	13 (100%)		0.079[f]
	Mean HB n ± SD	10.08 ± 1.22	9.26 ± 1.18	5.61	**0.02**
S. mansoni	Anaemia n(%)	144 (77.84)	58 (77.33%)	0.01	0.92
	Mean HB n ± SD	10.01 ± 1.23	10.12 ± 1.25	0.40	0.53
Schistosoma. spp	Anaemia n(%)	134 (76.57%)	68 (80.00%)	0.22	0.64
	Mean HB n ± SD	10.05 ± 1.21	10.02 ± 1.28	0.04	0.84

*Chi-square (χ^2) for the prevalence of anaemia and Anova F for mean haemoglobin concentration; [f]: Fisher exact test.

The prevalence of anaemia as well as haemoglobin levels were not significantly affected by *S. mansoni* infection (Table 6).

Discussion

Data from this study demonstrate that Schistosoma infection is prevalent among pregnant women and three species were found in Njombe-Penja health district. The disease is associated with young age, area of residence as well as blood group, especially for *S. haematobium* infection that is associated with a reduction of blood levels. They bring additional epidemiological information on schistosomiasis in adults and especially pregnant women, known to be more vulnerable to most infectious diseases with at least two lives at risk, those of the mother and the unborn child.

Three species of *Schistosoma* were found in our study population, which had been described in the country by Ratard *et al.* [32]. The prevalence of *Schistosoma* infection was 31.91%; thus, one third of pregnant women were infected. *S. guineensis* prevalence was very low, marking the gradual disappearance of this species in Njombe because of interspecific competition and introgressive hybridisation leading to its replacement by *S. haematobium* [8,33,34].

The prevalence of urinary schistosomiasis among pregnant women was 4.96%, not far from the national estimate of 6.1% [7]. Our result is similar to that reported by Siegrist and Siegrist-Obimpeh in Ghana (4.5%) [35]. However, it is lower than that reported in Nigeria by Eyo *et al.* [16], Salawu and Odaibo [18], and in Munyengue, South-West of Cameroon by Anchang-Kimbi *et al.* [20]. The study population in Munyengue (Cameroon) and in Nigeria was highly exposed to *S. haematobium* infection, due to their absolute dependence on natural water sources for domestic activities and bathing. In Njombe-Penja health district, there is a pipe network for the supply of potable water, which to some extent reduces the contact with natural water bodies, thus the exposure to infective worms. In addition, as reported by Tchuem Tchuente *et al.* [12], the number of *S. haematobium* high transmission foci have increased in the South-West region as compared with findings from the 1985-1987 mapping by Ratard *et al.* [32]. In fact, since 2005, Mass Drug Administration (MDA) for schoolchildren with praziquantel was implemented in two districts: Loum health district in the Littoral region (divided into Loum and Njombe-Penja health districts in 2012) and Mbonge in the South-West region. Munyenge that belongs to the Muyuka health district was thus not concerned. *S. haematobium* transmission have probably increased in the Munyengue area, Muyuka health district, while Loum and Njombe-Penja health districts in the Littoral region experienced a decline in the prevalence and transmission of the disease. Another possible explanation could be difference in the abundance of the *Bulinus* snail intermediate host.

The prevalence of *S. mansoni* was 28.01%, higher than that reported by Lehman *et al.* [24] and Payne *et al.* [,25] in this same study site. Our study population was aged 14 to 43 years while theirs were 0 to 77 years and 3 to 78 years, respectively. The difference could be due to the age range of study population as Mass Drug Administration (MDA) targets primary schoolchildren and our study participants were thus excluded. However, the prevalence of *S. mansoni* was more than five-fold higher than for *S. haematobium*. This might be due to the many factors including lower sensitivity of *S. mansoni* to praziquantel in participants who were treated during previous campaigns [36], insufficient coverage of MDA in the population in past years [37]. Also, differences in the abundance of host snails as well as in the transmission pattern of both species in the area should be considered.

S. haematobium infection was found only in women living in Njombe and the prevalence of *S. mansoni* infection was 7 fold higher in women living in Njombe than their counterparts from neighbouring settings. This shows that the transmission area for *S. mansoni* is wider than that of *S. haematobium*, and Njombe is the epicentre of schistosomiasis in the Njombe-Penja health district. Women of the O blood group were more susceptible to S. *haematobium* infection. This is not in line with previous findings [38,39] that showed the contrary. This might be due to the smaller sample size in our study and calls for further investigations in this area.

The prevalence of shistosomiasis was higher in younger women. This is in agreement with previous studies in Cameroon [20]. It is consistent with the general pattern in helminthic infections; the prevalence increases with age from infancy to adolescence, reaching a peak at the age of 19 then it starts declining [40]. Also, older women have reduced contact with water bodies as they usually commission their children for activities involving contact with water bodies. Age dependent immunity to *S. haematobium*, has also been shown to affect the prevalence and egg output in infected persons [41]. On the other hand, prevalence of shistosomiasis was higher in more educated women; this might be explained by the fact that level of education goes with age. An increase in education level

corresponds to increase in age and increased risk-behaviour. Probability of infection increases with age to a pick at 19 [40] that corresponds to the age for secondary and higher education. However, an increase in education may also correspond to increased awareness, hence reduced burden of the disease. A previous study including adult participants found a similar trend [42].

Infection with *S. haematobium* had a negative effect, causing a reduction of blood levels. The contribution of schistosomiasis in inducing anaemia in pregnant women has been documented [16]. The findings in this study are consistent with previous studies. Four mechanisms by which *Schistosoma* infections lead to anaemia have been suggested. They include extracorporeal loss of iron through frank or occult hemorrage due to egg passage across the intestinal or the bladder wall; sequestration and hemolysis of red blood cells in a context of splenomegaly due to portal hypertension; elevated levels of pro-inflammatory cytokines in response to infection with subsequent drop in erythropoiesis; autoimmune hemolysis of red blood cells [43]. Anaemia exposes the pregnant woman and her foetus to adverse pregnancy effects such as maternal death and low-birth weight with subsequent infant mortality. There was however, no significant overall difference in haemoglobin levels and prevalence of anaemia between women infected with *S. mansoni* and those uninfected. This is consistent with previous findings [43,44].

Some of the limitations of our study are that we did not investigate contact with water bodies as a determinant of schistosomiasis, the association of schistosomiasis with anaemia left out possible infection with other blood parasites and the sample size.

Conclusions

Schistosomiasis was found in one-third of pregnant women. Younger women and women residing in the town of Njombe were more affected. Infected women had lower blood levels, which could lead to adverse pregnancy outcomes. This calls for the continuation and intensification of ongoing control interventions including adequate water supply, sanitization efforts, mass drug administration in schoolchildren and behavioural change for the elimination of the disease in the area. Also, the national control program should consider female of childbearing age for mass drug administration.

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