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Survey of schistosomiasis and associated risk factors amongst residents of suburban riverine communities in Makurdi, Nigeria – Zoonotic implication

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Abstract

Schistosomiasis is a neglected tropical disease prevalent in underprivileged suburban and rural dwellers, characterised by poverty, poor sanitation and lack of basic amenities. Most published studies on schistosomiasis in Benue State are school-based, with a dearth of information about the disease epidemiology in suburban riverine communities. The current study aimed to determine the prevalence of urogenital and intestinal schistosomiasis and associated risk factors in residents of some suburban riverine communities in Makurdi, Nigeria. A cross-sectional study was designed in which stool and urine samples were collected from 452 participants from three riverine communities, after due consent was obtained. Samples were screened for *Schistosoma haematobium* and *Schistosoma mansoni* using centrifugation to enhance the sedimentation of eggs and Kato-Katz techniques, respectively. Information on participants' demography and water contact activities was obtained using a structured questionnaire. Results revealed an overall prevalence of 16.8%. Specific prevalence for urogenital and intestinal schistosomiasis was 16.4% and 0.4% respectively. 0ne case (0.2%) of ectopic *Schistosoma mansoni* was recorded. Specific prevalence for Agyetashi, Afubo and Ijaha communities were 3.8%, 2.5% and 27.4% respectively. Infected participants mostly had light intensity (98.7%) of infection. While haematuria was significantly associated with schistosomiasis ($p = 0.000$), proteinuria was not ($p = 0.384$). Age and sex were not determinants of the infection ($p > 0.05$). Multivariate analysis confirmed that the participants' community, proximity to open water bodies and drinking from open water bodies were the key factors significantly associated with schistosomiasis among the residents. Participants who occasionally engaged in open water activities were significantly more infected than those who regularly engaged in these activities. The study has shown the endemicity of schistosomiasis in Benue State. The authors recommend mass administration of praziquantel to the studied communities and public education to prevent exposure to the parasite.

Keywords: Intestinal, Makurdi, Nigeria, Prevalence, Riverine communities, Schistosoma, Urogenital

Introduction

Schistosomiasis, also known as Bilharzia, is a neglected tropical disease that remains a public health concern in developing nations in the tropics and subtropics. Approximately 240 million people are affected, and another 700 million are at risk of infection globally (Bruun & Aagaard, 2008). The African region has the highest burden of schistosomiasis, of which Nigeria has the highest burden and where 27.8 million people require preventive chemotherapy for schistosomiasis (WHO, 2022). Schistosomiasis and soil-transmitted helminths (STH) are neglected tropical diseases (NTDs) and are transmitted mainly in areas with poor access to clean water and sanitation (WHO, 2022). The presence of an intermediate snail host in water is essential to allow *Schistosoma* to complete its life cycle (WHO, 2022). Humans become infected when they encounter cercaria-infested water (cercaria released by the snail host), which penetrates the skin and initiates several developmental stages in the affected individual. Human schistosomiasis is caused mainly by three schistosome species: *Schistosoma haematobium*, *S. mansoni* and *S. japonicum*. *Schistosoma guineensis*, *S. intercalatum* and *S. mekongi* are highly localized in Central Africa and South-East Asia, respectively (WHO, 2022). Evidence of hybridizations between human and animal schistosomes has been reported in human and animals (Leger & Webster, 2017, Onyekwere *et al*., 2022), resulting to zoonotic hybrids. Urogenital schistosomiasis caused by *S. haematobium* is characterised by haematuria, dysuria, bladder cancer, and hydronephrosis (Barsoum, 2013). Infected adults may develop vaginal ulcers and other lesions which can result in poor reproductive health, including infertility and sexual dysfunction (Swai *et al*., 2006). Chronic intestinal disease can lead to hepatomegaly, splenomegaly, and progressive periportal fibrosis, resulting in portal hypertension, esophageal varices, liver surface irregularities, portal-systemic venous shunts, and haematemesis (King & Dangerfield-Cha, 2008).

Previous studies have reported the prevalence of schistosomiasis in many parts of Nigeria (Njoku *et al*., 2014; Joseph *et al*., 2017; Onyekwere *et al*., 2022; Angbalaga *et al*., 2024; Okpete & Ani, 2024). In Benue state prevalence ranging from 4.3% to 55.0% has been reported (Amuta & Houmsou, 2014; Uweh, *et al.,* 2015; Adulugba & Omudu, 2015; Obisike *et al.,* 2021). However, most of the studies were conducted in school-aged children, with a dearth of information on the epidemiology of the disease in high-risk communities such as suburban riverine communities. Also, there are limited studies on intestinal schistosomiasis in the state. A recent study demonstrated evidence of schistosome hybrids infecting school children in Nigeria indicating that similar transmission could be occurring in high-risk communities and could have consequences on the control of this disease (Onyekwere *et al*., 2022). Therefore, the current study was designed to determine the prevalence of schistosomiasis and associated risk factors in some suburban riverine communities in Makurdi, Benue state, Nigeria.

Materials and Methods

Ethical consideration

Ethical approval was obtained from the ethics committee of the Benue State Ministry of Health and Human Services, with the reference number, MOH/OFF340/VOL.4/P899. Before the commencement of the study, approval was also obtained from the district heads of the sampled communities; Agyetashi, Afubo, and Ijaha communities. Residents of the study locations were informed about the study objectives and written, and signed consent was obtained from them. In situations where minors were involved, consent was obtained from their parents or guardians.

Study area and study population

The present study was carried out in three suburban riverine communities in Makurdi town, Benue State, Nigeria, namely Agyetashi (GPS: 7.752874, 8.528950), Afubo Island (GPS: 7.751103, 8.501749) and Ijaha (GPS: 7.738731, 8.494214) (Figure 1). Makurdi is the capital city of Benue State, with a projected population of 472,000 (Macrotrends, 2024). The town is divided by river Benue into the north and south banks connected by two bridges: the railway bridge, and the dual carriage bridge. Makurdi town lies in the North-Central zone of Nigeria, with DMS latitude longitude coordinates of 7°44'27.96"N, 8°30'43.56"E. Residents of Agyetashi and Afubo communities are mainly Jukun, with a few Hausa and Tiv natives. Ijaha is a small community that lies along the southern bank of River Benue, with residents mainly Jukun and Idoma (Agatu) and a few Tiv natives. The main occupation of residents in these communities are fishing, small-scale farming and petty trading.

Sample Size determination

Sample size was determined using the formula for cross-sectional studies (Thrusfield & Christley, 2018). Using an expected prevalence of 25.7% (Obisike *et al*., 2018) for *S. haematobium*, a minimum sample size of 293 was calculated. However, the sample size was increased to 452 to account for sampling errors that may have arisen. The same sample size was used to determine the prevalence of *S. mansoni* in the study.

Study design and sampling

A cross-sectional community-based study was carried out among residents of the study locations, aged one (1) year and above. Communities were selected based on their proximity to the river Benue. Samples were collected from the residents based on their willingness to participate in the study (convenience sampling) after being informed and educated about the objectives of the study. Inclusion criteria for the study required volunteers to be residents of the community, and have duly signed the consent form, and not less than one (1) year old. Individuals who were below one (1) year of age and non-residents of the community were excluded from the study. Sampling and other data collection was done for a period of seven months, from May to November 2021.

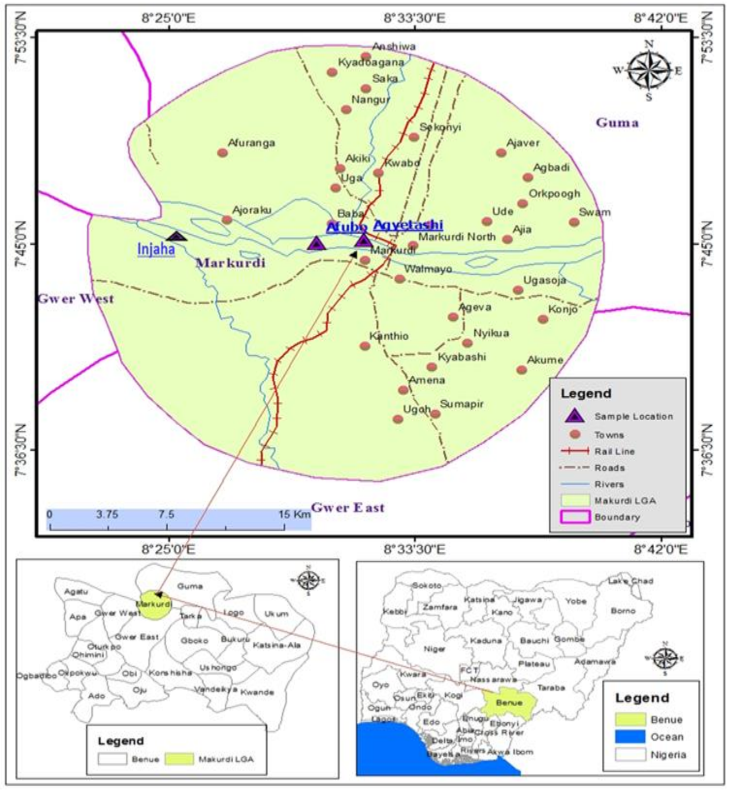

Figure 1: Map of Benue state showing study locations (Source: GIS Lab, Department of Geography and Environmental Management, A.B.U., Zaria)

Questionnaire survey

Pre-tested structured questionnaires administered to the study participants in the form of an interview were used to collect data about participants' demography and water contact activities. Survey questions as published by Sady *et al.* (2013) were adapted and modified for use in the current study. Some of the practices assessed included drinking water from open water bodies (OWB), swimming, bathing or fishing in OWB, defecating and/or urinating in OWB, use of OWB for household activities and irrigation farming. For proximity to OWB, participants who had river or stream or lake close to where there live or within the vicinity of their dwellings were termed to be close to OWB, while those whose dwellings were far from river or stream or lake and do not have these features within the vicinity of their houses were termed to be distant from OWB. A rapid assessment tool used by previous studies (Tanner *et al*., 1987; Lengeler *et al*., 1991) was also administered to the study participants to determine symptoms and conditions that were experienced by the participants within one month of sampling.

Sample collection

Urine and faecal samples were collected from each study participant. Each sample was appropriately labelled, indicating the sample identity number for each study participant. Sampling was done between 09:00 and 13:00 hours during which maximum egg output was likely to occur. Adult participants were advised to collect their urine midstream and exert pressure on their pelvic muscles so that the very last drop of urine was included in the samples. For children below 5 years, parents were advised to collect any voided urine and stool during the specified time for sample collection. Those who did not feel the urge to defaecate or urinate were asked to return the next day with fresh feacal and urine samples of that day inside their sample bottles. Samples were placed in cool boxes and transported within three hours to the Veterinary Parasitology laboratory of the Veterinary Teaching Hospital, Joseph Sarwuan Tarka University Makurdi, Nigeria, for processing**.**

Parasitological examination of samples

Urine samples were examined by centrifugation technique (Cheesbrough, 2009), and dipstick test using ACCU-ANSWER® Uric 10 CF (Guilin Zhonghui Technology, China) according to the manufacturer's instructions. Presence or absence of haematuria and proteinuria were noted while testing the samples. Egg counts were obtained and recorded as eggs/10 ml urine (ep10ml), and infection intensity was classified as light (1-50 ep10ml) or heavy (>50 ep10ml) (WHO,

2002) under ×40 magnification. For *S. mansoni*, faecal samples were examined using the Kato-Katz technique for the presence of *S. mansoni* eggs (Cheesbrough, 2009). To quantify the worm load in faeces, egg counts were obtained and reported as eggs per gram (epg) of faeces for each positive sample, and infection intensity was categorized as light (1-99 epg, moderate (100-399 epg) and heavy (400 epg) (WHO, 2002).

Data analysis

Data were entered into a spreadsheet (Microsoft Excel® 2016) and exported to IBM SPSS® Statistics vs 25.0 (IBM Corporation, NY, USA) for analysis. Data was subjected to descriptive statistics, calculating frequencies and percentages. Apparent prevalence was calculated by dividing the number of infected individuals by the total number of individuals examined and expressed as a percentage, and the confidence interval was calculated. The logistic regression was used to determine factors significantly associated with schistosomiasis. Variables assessed to be statistically significant at $p < 0.05$ were subjected to multivariate binary logistic regression using a backwards elimination method to determine covariates which were significantly associated with schistosomiasis at a probability of 5% ($p < 0.05$). The Odds ratio of these associations was noted while adopting a confidence interval of 95%.

Results

A total of 452 participants between the ages of 1 and 60 years, with a mean age of 16.3±13.6 years, from the three sampled communities enrolled in the study. Out of 452, 259 (57.3%) and 193 (42.7%) were males and females, respectively. According to age group, participants between 6-19 years were most enrolled in the study (244, 54.0%). Out of 452 participants, 160 (35.4%) lived in Agyetashi, 40 (8.8%) in Afubo, and 252 (55.6%) in Ijaha communities. Four hundred and thirty-eight (96.9%) participants lived close to the river Benue, while 14 (3.1%) lived distant from the river. Out of 452 participants, 237 (52.4%), 104 (23.0%), and 175 (38.7%) were involved in fishing, farming, and other jobs, respectively (Table 1).

The overall prevalence of schistosomiasis was found to be 16.8% (CI: 13.37% – 20.26%). Specific prevalence for Agyetashi, Afubo and Ijaha communities were found to be at 3.8%, 2.5% and 27.4% respectively (Table 2). Specific prevalence of *Schistosoma haematobium* was 16.4% (CI: 12.96% – 19.78%), whereas *S. mansoni* was 0.4% (CI: 0.00% – 1.05%). One case (0.2%) of ectopic *S. mansoni* (*S.*

Table 1: General characteristics of residents who participated in the study, Makurdi, Nigeria (n = 452)

Characteristics	n (%)
Community	
Agyetashi	160 (35.4)
Afubo	40 (8.8)
Ijaha	252 (55.8)
Age (years)	
1-5	78 (17.3)
6-19	244 (54.0)
20-60	130 (28.8)
Gender	
Male	259 (57.3)
Female	193 (42.7)
Proximity to OWB	
Near	438 (96.9)
Far	14 (3.1)
Fishing occupation	
No	215 (47.6)
Yes	237 (52.4)
Farming occupation	
No	348 (77.0)
Yes	104 (23.0)
Other jobs	
No	277 (61.3)
Yes	175 (38.7)

*n= number of participants

Table 2: Prevalence of *Schistosoma haematobium* and *Schistosoma mansoni* infection in the communities studied in Makurdi, Benue State

Community	NE (%)	*Sh* + (%)	*Sm* + (%)	Prevalence (%)
Agyetashi	160 (35.4)	6 (3.8)	0(0)	6 (3.8)
Afubo	40 (8.8)	1 (2.5)	0 (0)	1 (2.5)
Ijaha	252 (55.8)	67 (26.6)	2 (0.8)	69 (27.4)
Total	452 (100)	74 (16.4)	2 (0.4)	76 (16.8)

NE = Number examined, *Sh* **=** *Schistosoma haematobium, Sm = Schistosoma mansoni*

Table 3: Intensity of infection and mean count of *Schistosoma* species among study participants, Makurdi, Benue State (n = 452)

	S. haematobium			*S. mansoni*		
Intensity	N	%	Mean (ep10ml)	N	%	Epg
Light	73	98.6	3	2	100	81
Medium	-	-	-	-	-	-
Heavy	1	1.4	165	-	-	-
Total	74	16.4	4	2	0.4	81

N= number positive, ep10ml = egg per 10ml of urine, epg = egg per gram of faeces

Table 4: Association between haematuria, proteinuria and schistosomiasis among study participants, Makurdi, Benue State

		Schistosomiasis				
Variable		Positive (%)	Negative (%)	Total (%)	P value	OR (95% CI)
Haematuria	Positive	69 (46.3)	80 (53.7)	149 (100)	0.000*	36.47 (16.13-82.46)
	Negative	7 (2.3)	296 (97.7)	303 (100)		
	Total	76 (16.8)	376 (83.2)	452 (100)		
Proteinuria						
	Positive	29 (19.0)	124 (81.0)	153 (100)	0.384	1.25 (0.75-2.09)
	Negative	47 (15.7)	252 (84.3)	299 (100)		
	Total	76 (16.8)	376 (83.2)	452 (100)		

*Significant association at α = 5%, OR= odds ratio, CI = confidence interval

mansoni eggs in urine) was recorded in Ijaha community. There was no case of mixed infection. Out of the 3 communities studied, Ijaha community was most infected (27.4%) (Table 2). Generally, infected participants mostly had light (75/76, 98.7%) intensity than heavy (1/76, 1.3%) intensity of infection (Table 3). Haematuria and proteinuria were detected in urine samples of 33% and 34% of the study participants respectively. While haematuria was significantly associated with schistosomiasis (p = 0.000), proteinuria was not (p = 0.384) (Table 4).

Table 5 shows that the community a participant belonged to was significantly associated with schistosomiasis (p = 0.000). Ijaha community was most infected (27.4%) while Afubo was least infected (2.5%). Participants residing in Ijaha were 9.7 times more likely to be infected with schistosomiasis than those residing in Agyetashi. Although age and gender were not significantly associated with schistosomiasis, participants within the age group 6-19 years (19.7%), and male participants (18.9%) were mostly infected. Interestingly, participants that lived far from open water bodies were mostly infected than those that lived close (71.4% vs. 15.1%; p = 0.000). Whereas farming occupation was significantly associated with schistosomiasis (p = 0.025, OR = 1.8, 95% CI: 1.08-3.16), fishing and other job types were not (p > 0.05) (Table 5).

Table 6 shows that all accessed participants' practices towards open water bodies significantly influenced participants becoming infected or not (p < 0.05). These practices included swimming/bathing, defeacating/urinating, and fishing in OWB, use of water from OWB for household activities, washing of clothes/utensils and irrigation farming, and drinking water from OWB. While regular water contact activities lead to a decreased risk to schistosomiasis, occasional exposure to certain factors/practices led to an increased risk (Table 6). These practices included defeacating and washing clothes or utensils in OWB, and consuming water from OWB (Table 6).

Table 5: Association of schistosomiasis and demographic factors of study participants, Makurdi, Benue State (n = 452)

Variable	TS	NP	%P	P value	OR	95% CI
Community				0.000*		
¶Agyetashi	160	6	3.8			
Afubo	40	1	2.5	0.702	0.658	0.077 - 5.627
Ijaha	252	69	27.4	0.000	9.678	4.090 - 22.90
Age (years)				0.180		
¶1-5	78	12	15.4			
6-19	244	48	19.7	0.398	1.347	0.675 – 2.689
20-60	130	16	12.3	0.530	0.772	0.344 – 1.731
Gender						
¶Male	259	49	18.9			
Female	193	27	14.0	0.166	0.697	0.418 - 1.163
Proximity to OWB						
¶Near	438	66	15.1			
Far	14	10	71.4	0.000*	14.091	4.292 - 46.258
Fishing occupation						
¶No	215	39	18.1			
Yes	237	37	15.6	0.473	0.835	0.510 - 1.367
Farming occupation						
¶No	348	51	14.7			
Yes	104	25	24.0	0.025*	1.843	1.075 – 3.159
Other jobs						
¶No	277	43	15.5			
Yes	175	33	18.9	0.357	1.265	0.768 – 2.083

¶reference category, TS = total sampled, NP = number positive, %P = percentage positive, *Significant association at α = 5%, OR= odds ratio, CI = confidence interval

Results showed that those who reportedly defecate in OWB occasionally were 3.6 times more likely to be (P = 0.001, OR = 3.601, 95%CI = 1.721-7.538). Similarly, participants who reportedly wash clothes or utensils occasionally in OWB were 1.9 times more likely to be infected with schistosomiasis than those who do not wash clothes/utensils in OWB (P = 0.033, OR = 1.942, 95% CI = 1.053 – 3.581). Participants who reportedly drank water from OWB occasionally were 2.9 times more likely to be infected than those who do not drink water from OWB (P = 0.019, OR = 2.917, 95% CI = 1.193 – 7.132) (Table 6).

Three factors associated significantly with schistosomiasis were retained by multiple regression analysis (Table 7). Participants who resided in Ijaha had an adjusted OR of 5.9 when compared to those who lived in Agyetashi (95%CI = 2.356 – 14.683). Similarly, the odds of participants who lived far from OWB were significantly lowered but were still higher than those who lived close to OWB (adjusted OR = 7.3, 95%CI = 2.161 – 24.432). Participants who occasionally drank water from OWB had higher odds of schistosomiasis than those who always drank from OWB (adjusted OR = 2.7, 95%CI = 1.068 – 6.830) (Table 7).

At univariate analysis, five symptoms/conditions reported by the participants were significantly associated with schistosomiasis (Table 8). These included blood in urine, blood in stool, diarrhoea, respiratory infection and helminthosis, but at multivariate analysis, only blood in urine remained significant (p = 0.001). Participants who reportedly experienced blood in urine were 2.7 times more likely to be infected with schistosomiasis than those who did not experience the symptom one month preceding sampling (95% CI = 1.612 - 4.666) (Table 8).

Discussion

Schistosomiasis is a serious public health issue in many underdeveloped countries, especially in rural communities (Bruun & Aagaard-Hansen, 2008). Based on the prevalence (16.8%) recorded in this study, the disease is moderately endemic as classified by the World Health Organisation (WHO Expert Committee, 2002). The current study agrees with previous studies (Uweh *et al*., 2015; Obisike *et al*., 2018) that reported similar endemicity (8.1% and 25.7%, respectively) in Makurdi. While these studies sampled primary school

Table 6: Association of schistosomiasis and study participants' water contact activities, Makurdi, Benue State (n = 452)

Variables	TS	NP	%P	P value	OR	95% CI
Swim/bath in OWB				0.000*		
¶No	73	13	17.8			
Yes occasionally	211	51	24.2	0.264	1.471	0.747 –2.896
Yes always	168	12	7.1	0.016	0.335	0.153 – 0.822*
Defaecate/urinate in OWB				0.002*		
¶No	67	9	13.4			
Yes occasionally	262	58	22.1	0.119	1.832	0.857 – 3.919
Yes always	123	9	7.3	0.175	0.509	0.192 – 1.351
ǂYes occas vs Yes always				0.001	3.601	1.721– 7.538*
OWB for household use				0.000*		
¶No	57	9	15.8			
Yes occasionally	224	57	25.4	0.129	1.820	0.840 – 3.943
Yes always	171	10	5.8	0.024	0.331	0.127 – 0.862*
Wash clothes/utensils in OWB				0.000*		
¶No	107	16	15.0			
Yes occasionally	220	56	25.5	0.033	1.942	1.053 – 3.581*
Yes always	125	4	3.2	0.004	0.188	0.061 – 0.581*
Drink water from OWB				0.000*		
¶No	56	6	10.7			
Yes occasionally	243	63	25.9	0.019	2.917	1.193 – 7.132*
Yes always	153	7	4.6	0.114	0.400	0.128 – 1.245
Fish in rivers/streams				0.003*		
¶No	122	22	18.0			
Yes occasionally	198	44	22.2	0.369	1.299	0.734 –2.297
Yes always	132	10	7.6	0.015	0.373	0.169 –0.823*
OWB for Irrigation Farming						
¶No	282	57	20.2			
Yes	138	16	11.6	0.031*	0.518	0.285 – 0.940*

¶ = reference category, TS = total sampled, NP = number positive, %P = percentage positive
*Significant association at α = 5%, OR= odds ratio, CI = confidence interval, ǂ= Comparison between yes occasionally and yes always responses

Table 7: Factors associated with schistosomiasis among study participants retained at multivariate analysis

Variable	Adjusted OR	95% CI	P value
Community			0.000
¶Agyetashi			
Afubo	0.905	0.101 - 8.106	0.929
Ijaha	5.881	2.356 - 14.683	0.000*
Proximity to OWB			
¶Near			
Far	7.268	2.161 - 24.432	0.001*
Drinking from OWB			0.030
¶No			
Yes occasionally	2.397	0.946 - 6.072	0.065
Yes always	0.888	0.258 - 3.052	0.850
**Yes occas. vs Yes always	2.700	1.068 - 6.830	0.036*

¶ = reference category, OWB = open water body, *significant association at α = 5%, OR = odds ratio, CI = confidence interval, **= Comparison between yes occasionally and yes always responses

children mainly, the current study sampled residents in sub-urban riverine communities that mostly (96.9%) lived near open water bodies. Interestingly, a lower prevalence of schistosomiasis was observed in the current study compared to the studies conducted within the Makurdi metropolis. The authors expected

Table 8: Univariate analysis between schistosomiasis and symptoms reported by participants one-month preceding sampling

Variable	TS	NP	%P	P value	OR	95% CI
Blood in urine				0.001*		
No	228	23	10.1			
Yes	221	52	23.5	0.000	2.742	1.612 - 4.666*
I don't know	3	1	33.0	0.230	4.457	0.389 - 51.071
Blood in stool				0.036*		
No	263	34	12.9			
Yes	184	41	22.3	0.010	1.931	1.171 - 3.185*
I don't know	5	1	20.0	0.646	1.684	0.183 -15.515
Diarrhea				0.026*		
No	153	18	11.8			
Yes	293	55	18.8	0.060	1.733	0.978 - 3.073
I don't know	6	3	50.0	0.018	7.500	1.406 - 40.008*
Coughing				0.244		
No	179	25	14.0			
Yes	271	50	18.5	0.213	1.394	0.827 - 2.350
I don't know	2	1	50.0	0.204	6.160	0.373 - 101.689
Itching				0.396		
No	107	14	13.1			
Yes	342	61	17.8	0.252	1.442	0.771 - 2.698
I don't know	3	1	33.3	0.340	3.321	0.282 - 39.085
Headache				0.237		
No	110	14	12.7			
Yes	340	61	17.9	0.204	1.499	0.802 - 2.802
I don't know	2	1	50.0	0.182	6.857	0.405 - 115.96
Fever				0.000		
No	104	15	14.4	0.702		0.678 - 2.316
Yes	344	60	17.4	0.471	1.254	0.678 - 2.316
I don't know	4	1	25.0	0.566	1.978	0.193 - 20.294
Abdominal pain				0.374		
No	112	14	12.5			
Yes	334	61	18.3	0.161	1.564	0.837 - 2.922
I don't know	6	1	16.7	0.766	1.400	0.152 - 12.876
Eye disease				0.195		
No	173	24	13.9			
Yes	250	49	19.6	0.127	1.513	0.889 - 2.577
I don't know	29	3	10.3	0.607	0.716	0.201 - 2.552
Malaria				0.888		
No	135		16.3			
Yes	303		16.8	0.890	1.040	0.602 - 1.796
I don't know	14		21.4	0.626	1.401	0.361- 5.435
Respiratory infection				0.022*	1.868	1.59 - 3.296
No	299	47	15.7			
Yes	89	23	25.8	0.031	1.868	1.59 - 3.296*
I don't know	64	6	9.4	0.197	0.555	0.226 - 1.359
Helminthosis				0.006*		
No	199	22	11.1			
Yes	220	50	22.7	0.002	2.366	1.374 - 4.076*
I don't know	33	4	12.1	0.852	1.110	0.357 - 3.454

No = reference category, TS = total sampled, NP = number positive, %P = percentage positive, *significant association at α = 5%, OR= odds ratio, CI = confidence interval a high prevalence of schistosomiasis in riverine communities as residents live close to open water, and as a result, their open-water contact activities are expected to increase, leading to an increased risk to schistosomiasis. It is possible that regular exposure to open water activities by residents of these communities in some way boosted their immunity against *Schistosoma* infection, hence the lower prevalence as compared to studies on populations who lived far from open water bodies. There is clear evidence that indicates that protective immunity develops in people living in endemic areas, however very slowly (Fitzsimmons *et al*., 2012; Mutapi *et al*., 2013). An age-dependent acquisition of resistance to reinfection of *Schistosoma* was established, as children under the age of eleven are generally more susceptible to infection and reinfection in endemic areas than their adult counterparts, partly as a result of their history of exposure and infection intensity (Mitchell *et al*., 2011; McManus *et al*., 2018).There have been reports of high and low endemicity of schistosomiasis outside Makurdi local government area (Amuta & Houmsou, 2014; Obisike *et al*., 2021). Ezeh *et al*. (2019) in 50-year review classified Benue state as a hyperendemic zone for schistosomiasis.

When compared to other studies across Nigeria, moderate endemicity of schistosomiasis was reported in Jos, Plateau state (26.3%; Njoku *et al*., 2014), Kwara State (17.8%; Joseph *et al*., 2017), and Sankwala community of Cross River state (37.06%, Angbalaga *et al*., 2024). In contrast, lower prevalence (Ayuba *et al*., 2020) and higher prevalence (Singh *et al*., 2016; Okpete and Ani, 2024) of schistosomiasis has been reported in several parts of the country.

The prevalence of *S. mansoni* (0.4%) in the current study is low compared to earlier studies outside Makurdi LGA (Uweh *et al*., 2015; Adulugba & Omudu, 2015; Ikpe *et al*., 2020), with prevalence of 8%, 0.6% and 10.4% in Oju and Obi, Agatu, and Guma LGAs, respectively. Based on these studies, it is safe to conclude that the prevalence of *S. mansoni* is low in Benue State. Reasons for this conclusion cannot be explained now, but it is possible to assume that the distribution of the snail intermediate host for *S. mansoni* is low within the study area. When compared to studies outside Benue state, result of the current study is consistent with reports by Goselle *et al*. (2010), Pam *et al*. (2016), and Usman & Babeker (2017), which recorded low prevalence of intestinal schistosomiasis, 4.6%, 3.19%, and 0.15% in Plateau, Nasarawa and Bauchi states, respectively. Higher prevalence (Ahmad *et al*., 2015; Istifanus *et al*., 2018) of intestinal schistosomiasis has been reported in Dutse, Jigawa State (13.33%) and Bassa, Plateau State (15.8%) of Nigeria.

Interestingly, one case (0.2%) of ectopic *S. mansoni* (*S. mansoni* eggs in urine) was recorded in Ijaha community. Hybridization (interbreeding between two schistosomes species) is known to be responsible for ectopic egg elimination resulting in the detection of *S. mansoni* eggs in urine or *Schistosoma haematobium* eggs in faeces (Ratard *et al*., 1991; Cunin *et al*., 2003), and suggestive of possible sexual interaction in nature between *Schistosoma haematobium* and *S. mansoni* (Ojo *et al*., 2021). Previous studies reported ectopic *S. mansoni* prevalence of 2.2% (Okoli and Odaibo, 1999), 8% (Meurs *et al*., 2012) and 4.7% (Ojo *et al*., 2021).

Results from this study indicated that a greater proportion (98.7%) of the infected study participants had a light intensity of infection. The practices of the study participants may have contributed to this finding, as infection was most prevalent in individuals who occasionally engaged in open water contact activities. Hence, a low intensity of infection was observed. Also, the result observed could be explained by genetic and immunity factors that play important roles in the susceptibility of an individual to disease (Kouriba *et al*., 2005). Some previous studies reported similar findings of a higher proportion of low intensity of schistosomiasis (Amuta & Houmsou, 2014; Dawaki *et al*., 2016), while Noriode *et al*. (2018) reported otherwise.

A significant association was observed between haematuria and schistosomiasis in the current study, like previous studies (Ekpo *et al*., 2010; Ojo *et al*., 2021). Haematuria observed in urogenital schistosomiasis is caused by the presence of numerous calcified eggs in the bladder wall, which causes polyposis, hyperplasia, and severe ulceration, which can lead to haemorrhage (Santos *et al*., 2021). In severe stages of the disease, the bladder may calcify, leading to urethral blockage, hydronephrosis, and finally renal failure (Santos *et al*., 2021). Compared to microscopy, the detection of microhaematuria (33%) and proteinuria (33.8%) was higher in this present study. This finding is consistent with previous reports (Obisike *et al*., 2018; Gambo *et al*. (2021). In clinical diagnosis, haematuria caused by urinary schistosomiasis, especially *Schistosoma haematobium*, must be differentiated from other probable causes such as urinary tract infection, acute nephritis, renal tuberculosis, and cancer of the urogenital tract (Ponzo *et al*., 2024).

At multivariate analysis of significant risk factors, three factors remained significant. The current study indicated that the community of the participant, proximity to open water body and whether the participant drinks water from open water body played significant roles in determining the status of the individual. Therefore, individuals who were from Ijaha, lived far from an open water body and occasionally drinks water from an open water body were more likely to be infected with the *Schistosoma* parasite. Participants from Ijaha community were mostly infected and their odds of infection reduced from 9.7 to 5.9 when compared to participants from Agyetashi. It is suggestive that factors that encourages transmission and endemicity of schistosomiasis such as presence of intermediate snail host, presence of infected and susceptible individuals, and the practice of open defecation abounds in Ijaha when compared to the other communities. Demographically, Ijaha had more individuals that engaged in fishing and other activities that involved contact with open water. From personal observation and enquiries during sample collection, adults and children in Ijaha had more contact with the Benue River when compared to Agyetashi, as most times residents were out fishing or other activities during the sampling period. The high exposure to open water contact activities of Ijaha residents could have been responsible for the high prevalence recorded in the community.

Interestingly, results from the current study suggests that participant who lived far from open water bodies were 7.2 times more likely to be infected than those who lived close. This finding contrasts with that of Amuta & Houmsou (2014) who reported that closeness to open water was not a determinant of the disease. For the current study, it is possible to hypothesize that constant exposure to open water by those who lived close to open water body conferred some level of immunity, as opposed to those who lived far and had less contact with open water bodies. This theory was demonstrated in the practices of the participants when accessed at univariate analysis, as the disease was significantly more prevalent in those who occasionally swam/bath, defaecated, washed clothes/utensils, drank water from OWB (also significant at multivariate) and fish in OWB. Regular engagement in the forementioned activities indicated lower odds of schistosomiasis. When studying the immunology of human schistosomiasis, there are several factors to consider in the host–parasite relationships involving the different life stages of the parasites including invading cercariae, migrating schistosomula, adult worms and eggs deposited by adult female worms, exposed to the host immune system (Molehin, 2020). Because of the heterogeneity of human populations, the status of the individuals being studied plays an important role also (Molehin, 2020). There is clear evidence that shows that protective immunity does develop in people living in endemic areas, however very slowly (Fitzsimmons *et al*., 2012; Mutapi *et al*., 2013). Several studies support the hypothesis that the acquired schistosomiasis resistance observed in humans is linked to the stimulation of host protective immune responses to antigens released because of worm death (Mutapi *et al*., 1999; Pinot de Moira *et al*., 2013). Notwithstanding, it is important to note that the distribution of participants based on their proximity to OWB was skewed in favour of those that lived close to OWB (96.9% vs 3.1%), while most infected individuals lived far from OWB (15.1% vs 71.4%). The significant relationship and high odds ratio obtained may have been influenced by this distribution and may not be reflective of the true prevalence in the “far” population. Most importantly, the immunity of an individual play a vital role in determining whether the individual becomes infected or not.

Gender and age were not determinants of the disease in the current study. Though not significant, the disease was more prevalent in males than in females as reported by previous studies (Amuta & Houmsou, 2014; Obisike *et al*., 2018, Okpete & Ani, 2024). Similarly, the disease was more prevalent in participants who were 6-19 years. This age range represent children who are expected to be at primary and secondary school levels, representing an active force of the population who most probably are exposed to infected water as they carry out their chores.

Using a rapid testing method to assess for schistosomiasis (a method used by earlier studies) by enquiring from participants symptoms experienced in the month preceding sampling, we reported blood in urine (haematuria) as the only significant symptom at multivariate analysis. This is consistent with previous reports, validating haematuria as a symptom of schistosomiasis.

Zoonotic implication of the current study is that by consequence, *Schistosoma haematobium* and the snail intermediate host (*Bulinus sp*) are prevalent in the study area. It has been established that *Schistosoma haematobium* (a human schistosome) can hybridize with other animal schistosomes (such as *S. bovis or S. mattheei*) leading to the formation of hybrid schistosomes which are infective to both man and animals (Leger & Webster, 2017). *Schistosoma* hybrids can potentially cause an increase in transmission potential and morbidity and cause an altered response to drug therapy (Leger & Webster, 2017) for individuals residing in the study area, which could in turn affect control and preventive measures of the disease.

In conclusion, the current study reported the prevalence of urogenital and intestinal schistosomiasis in some riverine communities in Makurdi, Benue state. Participant's community, proximity to open water bodies and drinking from open water bodies were key factors associated with schistosomiasis. Participants' water contact activities were significantly associated with the disease, indicating that those who occasionally engaged in the assessed factors were more infected than those who regularly engaged in the activities and that regular open water contact activities led to lower odds of schistosomiasis. The authors recommend mass administration of praziquantel to the affected communities, depopulation of snail hosts and public education about the disease to prevent exposure to the parasite. In addition, future research should be carried out on snail and animal populations within and around the study area.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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