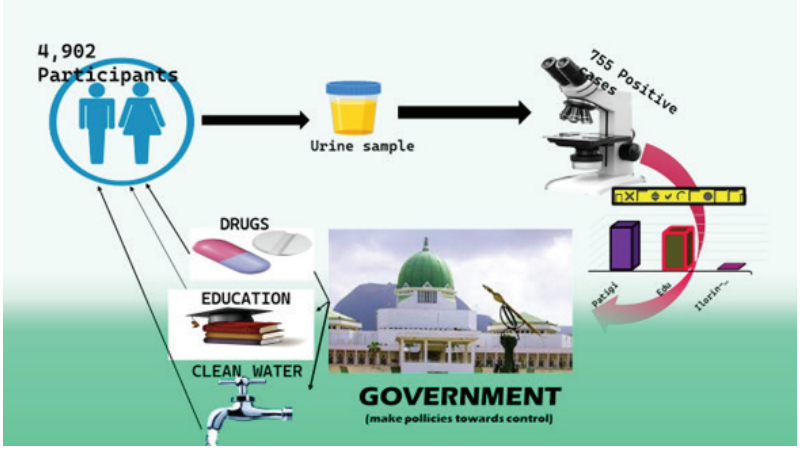
RESEARCH ARTICLE

Persistence of *Schistosoma haematobium* Transmission and Associated Risk Factors among Patients Living in Kwara State, North-Central Nigeria after Mass Drug Administration

Joseph O. Sunday*, Opeyemi G. Oso, Abdulkareem O. Babamale and Samuel U. Ugbomoiko



Highlights

- The overall prevalence of infection in Kwara State was 15.4% for preliminary survey
- One year post-treatment, 30.1% prevalence was recorded during the longitudinal study in the selected study areas (Edu, Patigi, and Ilorin South LGAs)
- Prevalence and intensity were high in Patigi (47.0%; 451.33±316.97) and low in Ilorin South (0.9%; 143.75±235.57)
- Prevalence, intensity, and morbidity were age- and sex-dependent
- Source of water supply, family income, occupation, and individual relationship with family head were common risk factors for infections in Edu and Patigi communities

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Persistence of *Schistosoma haematobium* Transmission and Associated Risk Factors among Patients Living in Kwara State, North-Central Nigeria after Mass Drug Administration

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Abstract: When an infected person urinates in a river, the aquatic environment becomes contaminated. The transmission to additional gullible people who come into contact with such an environment is known as the "ripple effect". This research examined the interactions between people and their surroundings, evaluating the likelihood, severity, morbidity, and risk factors of infection following the use of mass drug administration. Urine samples from 4,902 subjects were examined for *Schistosoma haematobium* using parasitological techniques, while semi-structured questionnaires were completed to obtain information on individual biodata and other epidemiological variables influencing transmission. During the preliminary survey, the overall infection prevalence in the studied areas was 15.4%, while one year post treatment, it increased to 30.1% in the selected study areas. In the Edu LGA, post-treatment infection rates in men increased from 46.6% to 53.9%, while those in women rose from 31.4% to 40.2%. Following treatment, the male rate in Patigi LGA fell from 48.7% to 35.9%, while the female rate fell from 44.1% to 28.8%. Age and gender had an impact on prevalence, intensity, and morbidity. Source of water supply (adjusted odds ratio (aOR) = 467.41 and 6.58), family income (aOR = 178.0 and 2.77), occupation (aOR = 4.00 and 1.55) and individual relationship with the head of the family (aOR = 0.14 and 0.67) were common risk factors for infection in Edu and Patigi communities. Infection was also linked to education (aOR = 4.23) and individual sex (aOR = 1.65) in Edu communities. Given the relatively high prevalence of *Schistosoma haematobium* in the study area, it is likely that schistosomiasis will continue to be a major public health concern in North Central Nigeria. Government organizations that are relevant should focus on long-term strategies for reducing schistosome infection.

***Keywords*:** Urinary Schistosomiasis; Risk factors; Intensity; Prevalence

INTRODUCTION

Schistosomiasis is a parasitic disease of public health concern that is widespread in rural areas and sub-Saharan countries. In this dynamic world, it is auspicious to understand how the disease spreads in response to the corresponding changes in the environment (Ellwanger et al., 2019; Gbalégba et al., 2017). Estimates of 239 million people are infected with schistosome in the world, with an annual loss of 1.7-4.5 million disability-adjusted life years (DALYs) (Hotez et al., 2014). This, however, did not consider indirect morbidity and mortality caused by the disease (Njunda et al., 2017). There are four species of the genus *Schistosoma* that causes human schistosomiasis worldwide: *Schistosoma mansoni, S. japonicum*, and *S. intercalatum* that causes intestinal schistosomiasis and *S. haematobium* responsible for urinary schistosomiasis (Pennance et al., 2020). In sub-Saharan Africa, the main burden of the disease is often attributed to *S. mansoni* and *S. haematobium*; the latter is more widely distributed in Nigeria (Adenowo et al., 2015).

The parasite is transmitted by freshwater bulinid snails. Infection occurs when eggs excreted in the urine of a human host hatch into a free-living ciliated miracidium under appropriate environmental conditions (optimal temperature and light). The Miracidium locates and invades a suitable snail host to begin intramolluscan development, ultimately leading to the production of hundreds of infective fork-tailed cercariae (Ross et al., 2015). Cercariae are released into the water by snails, actively swim and penetrate the skin of the human host. Within the host, it begins vertical migration to the host's perivascular venules, where it becomes a mature adult and lays eggs (Grimes et al., 2014). The terminal spine eggs clog the venous plexus and impede blood flow. Besides, the eggs elicit severe host inflammatory responses, largely characterized by helper2 T lymphocytes(IL-4, 5, and 13), polymorphonuclear leukocytes like eosinophils, and macrophages (Grimes et al., 2014). The clinicopathological effects of the disease vary depending on the intensity and type of parasite, ranging from haematuria (resulting from the rupture of the blocked veins) to inflammation (resulting from the upregulation of pro-inflammatory mediators such as chemokines and cytokines). This phase of the disease is characterized by parenchymal-mesenchymal transformation as granulomas become modulated, fibrotized, or calcified (Barsoum et al., 2013). Although not all infected individuals experience pathological sequelae, cases of haematuria, dysuria, hydronephrosis, nonfunctioning kidneys, cervical and squamous cell carcinoma of the bladder, and delayed physical and cognitive development are not uncommon (Coulibaly et al., 2017).

Schistosomiasis is one of twenty neglected tropical diseases (NTDs) targeted for global eradication by 2025 (WHO, 2012). Despite this elimination program, some factors

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still lead to schistosomiasis prevalence in various high-risk areas. These factors include the presence of irrigation dams, levels of poverty, polluted waters, socioeconomic status, inadequate access to clean water, inadequate basic infrastructure and inadequate environmental sanitation measures (Adenowo et al., 2015). The latest update shows that more than 221 million people in the world require preventative treatment, while in Africa alone, another 200 million required mass chemotherapy treatment in 2017. Meanwhile, an estimated number were unable to receive the treatment they needed (WHO, 2020).

A considerable number of rural communities in Nigeria are endemic to *S. haematobium* infection, with an estimated 101.28 million people at risk (Chitsulo et al., 2000; Houmsou et al., 2016). The disease has threatened the well-being of many populations in the country where it occurs, in virtually all states (Akinwale et al., 2015; Ugbomoiko et al., 2012). The prevalence and intensity of infection, especially among school children, has increased sharply in all cardinal zones of the country (Onasanya et al., 2021). However, basic information on at-risk preschool children and young adults remains sparse in some North Central states. In Kwara State (one of the north central states), previous studies have focused on the epidemiology and clinical impact of the disease in school children in built-up areas (Abdulkareem et al., 2018; Bolaji, 2015) while neglecting several other rural areas.

There is ample evidence in the literature that high-risk areas frequently employ chemotherapy to control schistosome infection (Dejon-Agobé et al., 2019). Mass drug administration has been demonstrated in southern Nigeria, where praziquantel is the drug of choice (Onasanya et al., 2021). However, in other African nations, the impact of praziquantel administered in large quantities yields inconsistent outcomes (French et al., 2015; Norton et al., 2010). Meanwhile, the strategy of mass drug administration combined with an adequate supply of clean water and snail control has led to significant progress in the control of *S. haematobium* infections over the past twenty years. Furthermore, effective control with chemotherapy depends on adequate and reliable baseline epidemiological data. There is an apparent lack of information on the geographical distribution of the disease in many areas of Kwara State. This requires urgent attention to improve the health status of the vulnerable population. The aim of this study was to provide the necessary data, the impact of mass drug administration and the risk factors associated with schistosome infection in the study areas.

MATERIALS AND METHODS

Study area

The study was conducted in the rural communities in all the 16 Local Government Areas of Kwara State. The State was created in January 1967 with the capital in Ilorin. The State is situated between latitude 8° and 10° N and longitude 3° and 6° E, covering an area of 36,825 km^2. The state has the Niger River as a natural border on the northern and eastern edges, Kogi State to the east, Oyo, Ekiti, and Osun States to the south and the Republic of Benin to the west. Drinking water supply is completely inadequate in many rural areas. Therefore, residents rely primarily on natural water supplies from streams, rivers or wells. The main economic activities of the rural population are trade, agriculture, animal husbandry, and fishing.

Study design

A preliminary survey was conducted in all sixteen LGAs between 2014 and 2016. All infected individuals were treated with a single dose of praziquantel. In 2017, two LGAs (Edu and Patigi) in rural areas and one LGA (Ilorin South) in urban settlements were selected for a follow-up study. Edu and Patigi LGAs were chosen because they had the highest infection rate while Ilorin South was chosen because it is one of the LGAs in the urban settlement. Before data collection, a door-to-door census of all households in the selected communities was carried out. Each household was assigned an identification number. Households were then randomly selected for inclusion in the survey. All members of the selected households in each of the communities were eligible to participate in the study. However, individuals who had spent less than 60 days in the selected community and individuals who received anti-schistosome treatment were excluded from the study.

Ethical considerations

Ethical approval (NERC/ASN/2014/011) was obtained from the Research and Ethical Committee, Faculty of Life Sciences, University of Ilorin, and Kwara State Ministry of Health Ethical Review Committee. The researchers visited the traditional leaders of the study communities to seek their cooperation. Thereafter, informed written consent was obtained from every adult participant and from the parents/caregiver of each child before they were enrolled in the study.

Data collection

All eligible individuals who volunteered to participate in the study were trained in the handling of urine samples. They were then given pre-labelled, wide-mouthed plastic containers with screw caps to collect their midday urine (between 10 a.m. and 2 p.m.) (Oyeyemi & Odaibo, 2017). Children who were unable to urinate immediately were given 20 to 30 minutes of exercise before being given sample bottles to collect their urine samples. All urine samples collected on each study day were transported to the laboratory for parasitological examination. The infection was confirmed by the presence of eggs in the urine.

Questionnaire administration

At the time of urine collection, all volunteers were administered a semi-structured questionnaire to obtain data on demographics (name, gender, marital status, length of residence of the person in the community, household size, educational background and religious background) as well as social-economic (occupation, average monthly income, household equipment and waste disposal system) and environmental/behavioural characteristics (timing of river visit, purpose of river visit, distance of river from residence and knowledge of symptoms).

Prevalence and intensity study

All urine samples were quantitatively examined for *S. haematobium* eggs within 48 hours of collection using the urine filtration technique (Richter, 2000). 10 ml of urine was drawn from the urine container into a syringe. A filter holder (Swinnex model, diameter 13 mm) equipped with a polycarbonate membrane filter (13 mm diameter and 12 µm pore size, Millipore Company, UK) was inserted into the syringe. The urine was slowly filtered through the filter membrane using the syringe plunger. The filter holder was unscrewed to carefully remove the filter with tweezers onto a clean, degreased slide. A drop of physiological saline was added before examination under a light microscope. The presence of eggs in urine confirms infection. The intensity of infection was classified as severe (>500 eggs/10 mL), moderate (51–499 eggs/10 mL), or mild (<50 eggs/10 mL) according to standard guidelines (Montresor et al., 1998).

Statistical analysis

The collected data were analyzed using IBM.SPSS (International Business Machine-Statistical Package for Social Science) software for Windows, version 22.0. The infection prevalence and the comparison of the gender and age proportions of the participants were determined using the chi-square test. Differences between means were tested using independent samples t-test and one-way ANOVA. Analysis of geometric egg counts was based on the infected individual in the population, while the population mean egg density was estimated as the burden of infection in the population studied.

RESULTS

In the preliminary examination, a total of 4,901 subjects, including 2,879 (58.7%) men and 2,023 (41.3%) women, were examined for *S. haematobium* infection (Table 1). Of the 4,901 participants, a total of 755 (15.4%) subjects had an infection. Of the 2879 men examined, 512 (17.8%) were infected, while a total of 243 (12.0%) infections occurred in women. The highest prevalence was recorded in Patigi LGA at 47.1%. In general, the prevalence of infection was significantly higher in men than in women, except in Kaima LGA where women had a higher prevalence. This trend was consistent across all sixteen LGAs (Table 1), with statistical analysis confirming a significant difference in infection rates between men and women ($p < 0.0001$). The total geometric egg intensity (GMI) for males and females was 401.85 ± 362.29 and 427.85 ± 351.61, respectively. In eight LGAs (Asa, Baruten, Edu, Ilorin East, Ilorin South, Isin, Kaiama and Oke Ero), egg burden was comparatively higher in males than females, while in Ekiti, Ifelodun, Ilorin West, Irepodun, Offa, Oyun and Patigi, the intensity of infection was higher in women than in men.

The distribution of egg production in relation to age and sex of infected individuals is shown in Figure 1. Of the infected population, 43.7% had mild infections (≥49 eggs/10 ml urine), 37.7% had moderate infections (50≥499). eggs/10 ml urine), while 18.5% had severe infections (≥ 500 eggs/10 ml urine). Higher infections were observed in all age groups except 0-5 years and those >40 years. Regarding gender, females had higher egg counts (≥500 eggs/10 ml urine) in all age groups except 16-20, 26-30 and >40 years.

Table 1: Prevalence of urinary schistosomiasis with respect to sex of subject in Kwara State, Nigeria.

LGA	Total		Male		Female		p-value
	Number examined	Number infected (%)	Number examined	Number infected (%)	Number examined	Number infected (%)	
Asa	266	62 (23.3)	156	42(26.9)	110	20(18.2)	0.07
Baruten	216	15(6.9)	129	12(9.3)	87	3(3.4)	0.08
Edu	389	158(40.6)	236	110(46.6)	153	48(31.4)	0.002
Ekiti	252	31(12.3)	156	23(14.7)	96	8(8.3)	0.09
Ifelodun	266	55(20.7)	161	38(23.6)	105	17(16.2)	0.09
Ilorin East	222	4(1.8)	127	3(2.4)	95	1(1.1)	0.41
Ilorin South	219	2(0.9)	137	2(1.5)	82	0(0)	0.40
Ilorin West	307	5(1.6)	185	3(1.6)	122	2(1.6)	0.50
Irepodun	315	12(3.8)	186	8(4.3)	129	4(3.1)	0.40
Isin	397	34(8.6)	235	27(11.5)	162	7(4.3)	0.01
Kaima	336	13(3.9)	186	6(3.2)	150	7(4.7)	0.70
Moro	381	73(19.2)	226	51(22.6)	155	22(5.8)	0.03
Offa	329	28(8.5)	171	17(9.9)	158	11(7.0)	0.20
Oke Ero	356	55(15.4)	206	35(17.0)	150	20(13.3)	0.20
Oyun	271	30(11.1)	148	21(14.2)	123	9(7.3)	0.05
Patigi	379	178(47.0)	234	114(48.7)	145	54(44.1)	0.20
TOTAL	**4901**	**755(15.4)**	**2879**	**512(17.8)**	**2022**	**243(12.0)**	**<0.0001**

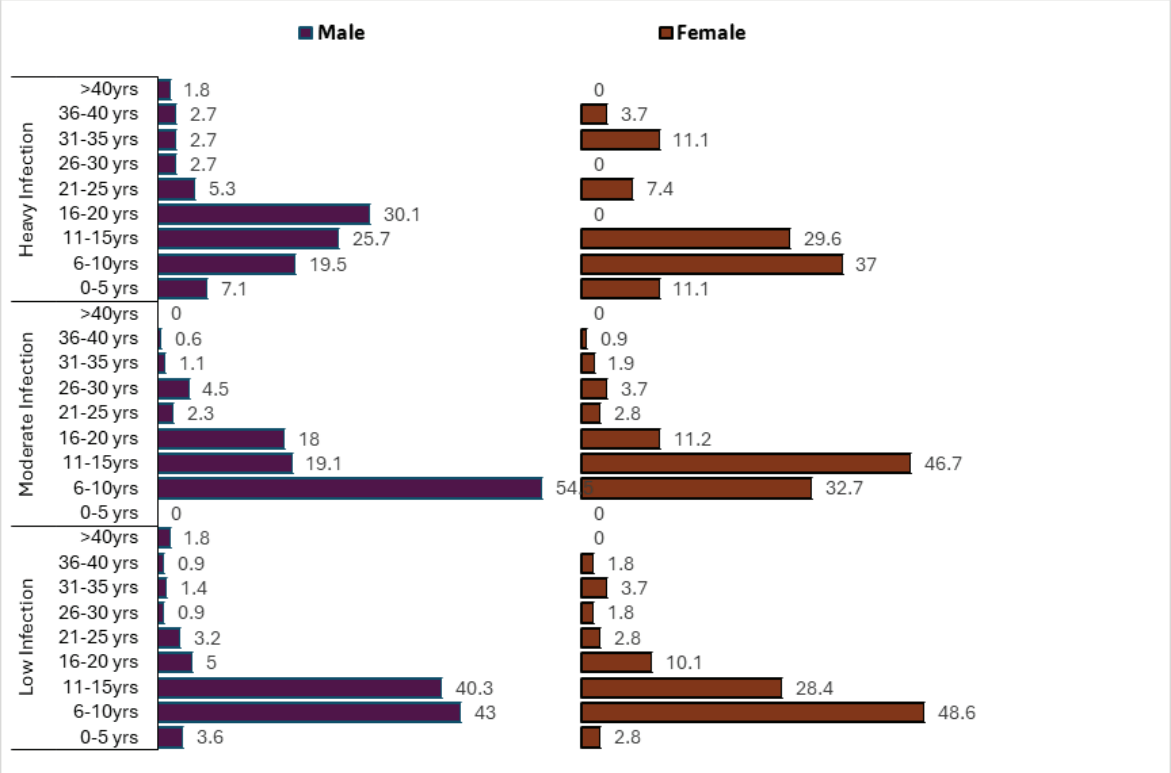


Figure 1: Intensity of infection of *Schistosoma haematobium* in relation to age and sex in Kwara State, Nigeria.

Infection status one-year after mass drug administration

The overall prevalence of schistosome infection in three sex-specific areas is shown in Table 2. The endemic areas had an overall prevalence of 30.1%, with Edu LGA recording the highest prevalence at 48.7%, followed by 33.1% in Patigi LGA. While gender prevalence was statistically different in the Edu and Patigi communities ($p < 0.05$), infection prevalence was consistently higher in men (33.6%) than women (24.8%) in all studied communities.

Table 2: Overall prevalence of urinary schistosomiasis one-year post treatment in the studied areas stratified with sex in Kwara State

LGA	Number Examined	Number Infected (%)	95% Confidence Interval
EDU			
Male	419	226 (53.9)	49.0 – 58.8
Female	261	105 (40.2)	34.3 – 46.5
p-value		0.001	
Sub-total	680	331 (48.7)	44.9 – 52.5
PATIGI			
Male	459	165 (35.9)	31.6 – 40.5
Female	302	87 (28.8)	23.8 – 34.3
p-value		0.03	
Sub-total	761	252 (33.1)	29.8 – 36.6
ILORIN SOUTH			
Male	294	3 (1.0)	0.26 – 3.2
Female	216	1 (0.5)	0.02 – 3.0
p-value		0.40	
Sub-total	510	4 (0.8)	0.25 – 2.1
TOTAL	**1951**	**587(30.1)**	**28.1 – 32.2**

The intensity of schistosome infection in the studied areas, stratified by the sex of the subjects, is shown in Table 3. Patigi LGA had the highest overall geometric egg intensity (422.3 ± 367.1). With the exception of Ilorin South, females generally had higher egg counts than males. However, there was no significant difference in egg count intensity between males and females except in Patigi LGA where females had significantly higher egg counts ($p < 0.05$). In Edu LGA, females showed slightly higher intensity (170.1 ± 213.9) than males (123 ± 214.3), while in Ilorin South LGA, males showed higher values (156.3 ± 165.8) compared to females (30.0 ± 0.00).

The infection status in the preliminary survey and one year after treatment with a single dose of praziquantel is shown in Figure 2. In the Edu LGA, men had an infection rate of 46.6% during the preliminary survey, which increased to 53.9% one year post-treatment while the infection rate in women was initially 31.4%, increasing to 40% one year after treatment. In Patigi LGA, infection in men was initially 48.7% and fell to 35.9% one year after treatment, while in women the infection was initially 44.1%, which fell to 28.8% one year after treatment.

In Ilorin South, infections were only observed in the ≤10 and 11-20 years age groups. In all stations examined, schistosome infection was higher in unmarried participants than in married subjects. The highest prevalence (66.6%) was recorded among unmarried persons in Edu LGA. The infection rate related to religion was higher among people

Table 3: Overall intensity of urinary schistosomiasis one-year post treatment in selected studied areas stratified with the sex of participants

LGA	Geometric Mean Intensity		Mean Population Egg Load	
EDU	**X±SD**	**95%CI**	**X±SD**	**95%CI**
Male	123.1± 214.3	95.0 – 151.2	66.4 ±168.8	50.2 – 82.6
Female	170.1 ± 213.9	128.6 – 211.5	68.4 ± 159.1	49.0 – 87.8
p-value	**0.065**		**0.89**	
Sub-total	138.0 ± 214.9	114.8 – 161.3	67.2 ± 165.0	54.8 – 79.6
PATIGI				
Male	382.4 ± 350.5	328.5 – 436.2	137.5 ± 278.8	111.9 – 163.0
Female	498.1 ± 387.3	415.5 – 580.6	143.5 ± 306.5	108.8 – 178.2
p-value	**0.017**		**0.78**	
Sub-total	422.3 ± 367.1	376.8 – 467.8	139.8 – 289.9	119.2 – 160.5
ILORIN SOUTH				
Male	156.3 ± 165.8	-255.5 – 568.2	1.60 ± 20.9	-0.8 – 3.9
Female	39.0 ± 0.00	0.00 – 0.00	0.18 ± 2.7	-0.18 – 0.54
p-value	**0.602**		**0.322**	
Sub-total	127.0 ± 147.5	-107.7 – 361.7	1.0 ± 15.9	-0.39 – 2.4

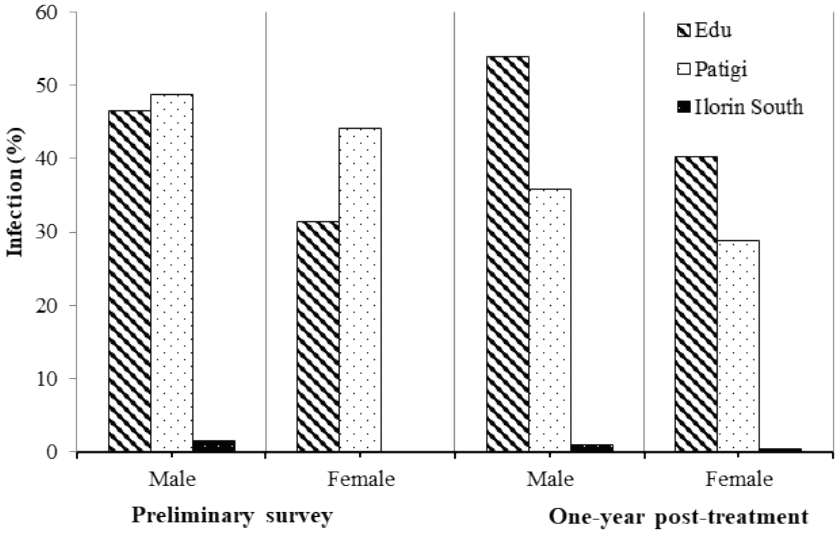


Figure 2: Infectious status during preliminary survey and one-year post-treatment in relation to sex and location

practicing Islam than among people of other religions (Table 4). Mean infection intensity was not significantly associated with gender in Edu LGA and Ilorin South LGA ($p > 0.05$), but there was a significant difference between mean intensity and gender in Patigi LGA ($p \leq 0.05$).

During this study, poverty was strongly associated with infections, with the lowest income group (≤₦18,000 per month) having the highest prevalence and intensity in both Edu and Patigi LGAs (Table 4). Those without access to toilets had a significantly higher prevalence and intensity of infection, with Edu LGA recording a prevalence of 89.2% and a mean intensity of 237.6 ± 156.6 and Patigi LGA recording a prevalence of 36.7% and a mean egg intensity of 453.7 ± 365.4. Socioeconomic factors such as occupation, family income, source of water, access to toilets, relationship with family head, and education level were significantly associated with infection rates in Edu and Patigi LGAs (Table 5).

Factors such as proximity to natural water bodies and frequency of visits were significantly associated with infection in Edu and Patigi LGAs. Notably, living near water bodies (<200 meters) was strongly associated with prevalence in all studied areas ($p<0.01$), with an infection rate of 93.7% in homes in this proximity in Edu LGA, followed by an infection rate of 87.3% for those living 200 to 500 meters from rivers and streams. Visiting open water bodies in Edu and Patigi LGAs was strongly associated with schistosome infection. Participants who swam in water bodies had the highest prevalence of infection, at 79.1% in the Edu LGA. Agriculture and fishing were associated with a prevalence of 64.0%, while washing had the lowest rate at 36.3%. The frequency of visits to water bodies correlated significantly with infection prevalence and intensity in all areas examined.

Table 4: Prevalence and intensity of urinary schistosomiasis in the studied stations in relation to demographic variables

PARAMETERS	N	EDU n (%)	Egg count X±SD	N	PATIGI n (%)	Egg count X±SD	N	ILORIN SOUTH n (%)	Egg count X±SD
SEX									
Male	419	226(53.9)	214.3±123.1	459	165(35.9)	382.4±350.5	294	3(1.0)	165.8±156.3
Female	261	105(40.2)	214.0±170.1	302	87(28.8)	498.1±387.4	216	1(0.5)	39.0±0
p-value		**0.001**	**0.65**		**0.041**	**0.017**		**0.48**	**0.60**
AGE									
0-10	203	128(63.1)	175.7±107.8	292	110(37.7)	472.2±368.3	182	2(1.1)	217.7±193.0
11-20	208	135(64.9)	265.6±209.2	320	121(37.8)	411.2±370.3	198	2(1.0)	61.0±21.2
21-30	93	31(33.3)	104.3±54.4	52	6(11.5)	295.2±294.6	46	0	-
31-40	98	25(25.5)	41.5±39.0	68	11(16.2)	296.8±247.6	58	0	-
≥41	78	12(15.4)	137.2±82.0	21	3(14.3)	68.0±11.4	28	0	-
p-value		**<0.0001**	**<0.0001**		**<0.0001**	**0.086**		**0.85**	**0.48**
MARITAL STATUS									
Single	419	279(66.6)	225.5±156.6	647	235(36.3)	438.9±368.9	412	4(1.0)	-
Married	261	52(19.9)	125.5±55.2	144	17(14.9)	256.7±203.6	98	0	-
p-value		<0.0001	0.003		<0.0001	0.025		0.37	
RELIGION									
Christianity	44	43(97.7)	310.6±302.4	97	16(16.5)	457.5±345.4	81	0	-
Islam	609	262(43.0)	185.0±109.6	636	232(36.5)	419.4±367.7	405	4(1.0)	-
Others	27	26(96.3)	188.6±151.2	28	4(14.3)	503.9±451.3	24	0	-
p-value		**<0.0001**	**<0.0001**		**<0.0001**	**0.91**		**0.59**	**<0.0001**
RELATIONSHIP WITH FAMILY HEAD									
Self	128	53(26.8)	59.9±28.0	43	8(18.6)	183.6±104.4	35	0	-
Spouse	79	5(6.3)	252.4±244.2	52	8(15.4)	302.9±291.6	45	0	-
Child	214	92(43.0)	246.3±183.0	590	198(33.6)	416.9±363.5	388	0	-
Ward	189	181(95.8)	216.0±144.4	76	38(50.0)	542.8±384.5	42	4(9.5)	-
p-value		**<0.0001**	**<0.0001**		**<0.0001**	**0.011**		**<0.0001**	**-**
FAMILY INCOME									
≤N18,000	361	192(53.2)	254.6±200.7	359	141(39.3)	421.3±374.2	229	1(0.4)	347.0±0
N18,000-N30,000	305	138(45.2)	226.5±155.7	400	109(27.3)	427.2±357.3	218	3(1.4)	53.7±19.6
≥N31,000	13	1(7.7)	578.0±0	-	-	-	63	0	-
p-value		**0.001**	**<0.0001**		**<0.0001**	**0.75**		**0.40**	**0.006**

PARAMETERS	N	EDU n (%)	Egg count X±SD	N	PATIGI n (%)	Egg count X±SD	N	ILORIN SOUTH n (%)	Egg count X±SD
PROXIMITY									
<100meters	95	89(93.7)	223.1±137.0	238	104(43.7)	437.8±361.3	1	0	-
100 – 200meters	173	151(87.3)	232.3±165.2	196	49(25.0)	487.2±381.7	5	0	-
≥1km	412	91(22.1)	166.1±93.9	327	99(30.3)	373.9±363.0	504	4(0.8)	-
p-value		<0.0001	0.44		<0.0001	0.18		0.98	
FREQ. OF VISIT									
Daily	208	201(96.6)	246.3±163.5	382	143(37.4)	448.3±361.0	16	0	-
Weekly	323	102(31.6)	133.5±85.7	291	87(29.9)	343.5±344.3	3	0	-
Monthly	149	28(18.8)	183.1±145.7	88	22(25.0)	565.4±438.3	242	0	-
Not at all	-	-	-	-	-	-	249	4(1.6)	-
p-value		**<0.0001**	**0.11**		**0.03**	**0.017**		**0.85**	
REASON FOR VISIT									
Washing	422	153(36.3)	118.0±72.3	327	52(15.9)	373.9±363.0	196	0	-
Farming & Fishing	172	110(64.0)	234.3±159.3	300	153(51.0)	453.6±367.5	65	0	-
Swimming	86	68(79.1)	124.2±35.8	134	47(35.1)	342.5±34.8	-	-	-
Not at all	-	-	-	-	-		249	4(1.6)	-
p-value		**<0.0001**	**0.001**		**0.15**	**0.65**		**0.04**	

Table 5: Multivariate logistic regression analysis of factors associated with *Schistosoma haematobium* infection

Variable	EDU			PATIGI		
	aOR	95%CI	P. value	aOR	95%CI	p-value
Sex	1.65	0.051 – 2.104	0.023	1.23	2.22-2.45	0.210
Education	4.23	2.901 – 4.833	<0.0001	-	-	-
Occupation	4.00	1.197 – 1.601	<0.0001	1.55	2.544 – 5.001	<0.0001
Income	178.0	1.700 – 3.010	<0.0001	2.77	2.830 – 6.010	<0.0001
Source of Water	467.4	2.00 - 2.835	<0.0001	6.58	1.714 – 2. 542	<0.0001
Relationship with Family Head	0.14	2.841 – 4.018	<0.0001	0.67	2.901 – 4.833	0.039

DISCUSSION

During the preliminary survey, an overall prevalence of *S. haematobium* infections of 15.4% was observed. One year after treatment, a prevalence of 30.1% was recorded in the three selected Local Government Areas (Edu, Patigi, and Ilorin South). This is considered low compared to 73.0% in Koya Minjibir Local Government Area of Kano State (Umar et al., 2016); 60.8% in Hamma-Ali community, Sokoto State (Singh & Muddasiru, 2014), and 65.3% in Ovia South West LGA of Edo State (Noriode et al., 2018). However, similar results were recorded in Yewa North LGA, Ogun State (Oyeyemi & Odaibo, 2017) and Biase LGA of Cross River State (Opara et al., 2021). The differences in prevalence between these studies may be influenced by particular ecological characteristics of local water bodies and the water contact practices of individuals in the population. Furthermore, the degree of exposure of individuals to infested waters and the availability of infected snail intermediate hosts in the natural waters could be attributed to the differences in infection status (Tumwebaze et al., 2019).

Comparison of community data showed a striking variation in the distribution pattern of urogenital schistosomiasis in the studied areas. For example, infection prevalence in communities varied between 0.0% and 61.3%, while in Local Government Areas (LGAs) it varied between 0.0% and 47.1%. These results are consistent with reports from other parts of Nigeria (Abdulkadir et al., 2017; Atalabi et al., 2016). The variation in infection prevalence across communities and LGAs recorded in this study could likely be due to the restriction of the snail intermediate hosts of the parasite to limited foci. Due to the lack of a suitable snail host, an area may not have an infection (Owojori et al., 2006). Also, previous investigators (Akinwale et al., 2015; Allen et al., 2017) have reported that the presence of a suitable snail intermediate host in an area may not guarantee the presence of the disease in other areas since the strain of a schistosome parasite from one locality may not infect a similar snail host from another location.

During this study, there were no infections in Okuta, Dalemo, Akata Oshode, Sabo-Oke, Sakama, Baboko and Tunga Aboki communities. This could be due to the

provision of piped water in these communities; therefore, there is limited contact with freshwater bodies. The highest prevalence of the disease was recorded in rural communities where there are slow-moving water bodies such as streams, flooded rice paddies, rivers and tributaries. This is similar to the findings in Osun State (Ugbomoiko et al., 2010), where the communities depended on infested natural water bodies for domestic, recreational, and economic activities. Also, in a meta-analysis, the prevalence of the infection varied by setting (Abdulkadir et al., 2017). They reported that infection prevalence is higher in rural populations than in urban communities. It has been observed that the prevalence of the infection can be as high as 97% in some areas of Africa, while the disease may not occur in areas not so far from water contact points (Ekpo et al., 2013). The lack of a suitable environment for snail intermediate hosts to thrive could be responsible for this observation. Elsewhere, the different prevalence of schistosome infection was due to various factors, including population density, frequency of contact with water bodies infested with S. *haematobium* cercaria, migration and poverty (Mtethiwa et al., 2015).

The prevalence of infection was not uniform in relation to the gender and age of the people in the areas examined. In the preliminary survey for the three selected LGAs, a prevalence of 37.2% and 26.8% was recorded for men and women, respectively. One year after treatment, overall infection was 33.6% in men and 24.8% in women. This showed a higher infection rate in men compared to women in both the pre-survey and post-treatment study. This is consistent with the results in Nigeria, where there was a significant association between urinary schistosomiasis and gender (Abdulkareem et al., 2018; Bolaji, 2015). This may relate to the level of exposure of the males to infested water bodies.

Many researchers have reported the association between the prevalence of schistosome infection and age (Noriode et al., 2018; Oyeyemi & Odaibo, 2017; Umar et al., 2016). In this study, the highest prevalence of the disease in the general population was recorded in 11-15 years. Thereafter, prevalence decreased with increasing age. This confirmed the previous findings (Dawaki et al., 2016; Oyeyemi & Odaibo, 2017). However, this differs from observations in Malawi (Kapito-Tembo et al., 2009) where a peak of infection was recorded in the age groups 11-13 years and 16-20 years, respectively. These age groups tend to be very active and are more likely to engage in activities with intensive water contact. This possibly justified the high infection prevalence in the age groups. Furthermore, the apparent socioeconomic differences and age-related changes observed in the study could be a likely justification for the decline in infections with increasing age. One study reported that from increasing age and the development of protective immunity, water contact activities in particular could be the main factors influencing this pattern (Ugbomoiko et al., 2012). Infection was reported in aged 0-5 years in this study. This is consistent with a study in Ogun State where a prevalence of 58.1% was recorded among 167 pre-school children (Ekpo et al., 2010). The fight against schistosome infection in Nigeria consists of mass drug administration in schools where there is a shortage of preschool children; Therefore, the treatment of this age group should be included in the control (Bassey et al., 2020). In this study, there was a reduction in infection prevalence in Patigi LGA one year after treatment with a single dose of praziquantel; however, the infection prevalence in Edu LGA did not decrease. Although praziquantel is the drug of choice for treating schistosome infections, the use of this drug must be regular to achieve effective results.

In all LGAs, infection intensity was recorded in relation to age. In the studied population, severe infections (≥500 eggs/10 ml urine) occurred more frequently in the 11 to 15 year age group. This is consistent with reports from previous workers in endemic communities in Nigeria (Ugbomoiko et al., 2010). The age- and sex-specific pattern of infection intensity in this study showed that younger age groups had a higher infection burden than older age groups. This increases the likelihood of high morbidity (decreased physical and mental functions, renal dysfunction, bladder outlet obstruction, bladder cancer and infertility) in this vulnerable age group (Adenowo et al., 2015). In addition, the varying exposure of individuals to infection influenced the distribution and intensity of infection with increasing age (Lund et al., 2021). They describe behavioural, immunological, genetic, and nutritional factors as potential causes of this infection bias. The overly distributed pattern of infection intensity with respect to population age and sex observed in this study may reflect the combined effects of infested waters, the amount and type of water contact, and the ability to build effective resistance to the infection. In this study, women were infected more often than men. The severe infection found in the females could be due to the long time they spent in water bodies washing cloths and other materials.

The occupational risk of urogenital schistosomiasis has been described in detail by some authors (Dawaki et al., 2016; Ugochukwu, 2013) and has been considered as an indicator of the type and intensity of water contact activities (Dawaki et al., 2016; Ugochukwu, 2013). In this study, a significant association between infections and type of employment was observed in the areas examined. Participants who worked in agriculture and fishing were observed to be more than three times more likely to be infected than participants who had paid employment. This is consistent with the report that an infection prevalence of 85% occurred among individuals engaged in fishing activities (Ugbomoiko et al., 2010). It was also observed that the probability of infection was approximately four times higher among students than among working subjects. Students are likely to be more exposed to sources of infection than working people. Students collect water for home use and may have more free time for swimming and other recreational activities.

The well-being of individual family members depends heavily on family size and income. In this study, urogenital schistosomiasis was strongly associated with poverty in all areas examined. Infection was observed to decrease as family income increased. The infection rate was highest in families earning less than Nigeria's minimum wage.

Family size was also found to be significantly related to infection. This finding is consistent with other reports in Osun State (Ugbomoiko & Ofoezie, 2007). Also, previous investigators have reported a correlation between poverty and schistosome infection in endemic settings (Abdulkareem et al., 2018; Bolaji, 2015).

Insufficient or poor levels of education are a risk factor for urinary schistosomiasis and many other parasitic diseases in developing countries (Dawaki et al., 2016). This study showed that the probability of infection is higher among people without primary education or with incomplete primary education than among people with higher education in the population studied. This is consistent with findings elsewhere where there was a strong association between poor education and the prevalence of urogenital schistosomiasis in various endemic communities (Aagaard-Hansen et al., 2009; Ugbomoiko et al., 2010). The observed pattern can be attributed to the fact that education influences attitudes and behaviour in different ways. Individuals with a low educational background are more likely to be exposed to cercariae invasion of natural water than those with higher education (Ugbomoiko et al., 2010).

The proximity of the subject's residence to open natural waters, the potential habitat of *S. haematobium*-infected snails, and the location where most transmission is likely to occur was significantly associated with the prevalence and intensity of urogenital schistosomiasis in this study. The study found that people whose residences were less than 200 meters from water were five times more likely to be infected than those whose residences were more than 500 meters from water. This is consistent with reports elsewhere (Adenowo et al., 2015; Dawaki et al., 2016). They suggested that proximity to the site of transmission may be a strong predictor of severe and moderate *S. haematobium* infection. Poor families living near a river would likely not find it necessary to bear the cost of alternative safe water sources to mitigate the intermittent supply of safe tap water. On the contrary, households with some knowledge of disease transmission and those living at a distance from the river were more likely to have alternative sources of water supply. In this study, infection was found to be strongly related to the reason for visits to open waters. Over 75% of people who visited local rivers to swim had urogenital schistosomiasis, while about 36% of those who visited the rivers to wash were infected. In Sokoto State, there was a strong association between exposure to aquatic environments and the intensity of infection (Singh & Muddasiru, 2014). According to Oladejo & Ofoezie (2006), the reason for water contact is for recreational and domestic purposes for members of rural communities. These rural communities seemed to prefer open water sources; therefore, contact with local rivers that might be contaminated with schistosome cercariae was more common.

It was observed that people without access to drinking water in the studied areas were almost four times more likely to be infected with *S. haematobium* than those with access to drinking water. Furthermore, those who visit open water bodies daily were three times more likely to be infected than those who visit the rivers no more than once a month in Edu LGA. In Patigi LGA, people who visit open water bodies daily were about six times more likely to be infected than those who visit rivers only once a month. Likewise, individuals living less than 100 meters from open water were twice as likely to be infected with *S. haematobium* as those living at least 1 km from open water in the Edu LGA. In Patigi, individuals living less than 100 meters from open water were approximately five times more likely to be infected with *S. haematobium* than those living at least 1 km from open water. Low-income earners (<₦18,000) who also had an incomplete primary education were more predisposed to schistosome infection compared to their counterparts whose monthly income exceeds ₦31,000 and had completed primary education in Edu LGA.

CONCLUSIONS

In summary, this comprehensive study provides valuable insights into the prevalence, distribution and determinants of urogenital schistosomiasis in rural communities in Nigeria, focusing on three Local Government Areas (LGAs): Edu, Patigi and Ilorin South. The results showed a significant burden of infection, although this prevalence is comparatively lower than some other regions of Nigeria, it highlights the ongoing challenge of schistosomiasis in the studied areas. The study highlighted several important factors that influence the prevalence and intensity of infection, including gender, age, socioeconomic status, occupation, education level and proximity to natural water bodies. Poverty, limited access to drinking water and pursuing high-risk jobs such as farming and fishing were strongly associated with increased infection rates. In addition, education level was found to be an important factor, as those with lower levels of education were more susceptible to infection. furthermore, the study highlighted the importance of regular mass drug administration campaigns and integrated control measures targeting high-risk groups, including preschool-aged children and those in jobs with significant water contact. It highlighted the need for sustained interventions to address socioeconomic inequalities, improve access to clean water and sanitation, and promote health education and awareness to reduce transmission and morbidity associated with schistosomiasis. Therefore, we recommend that the government should begin routine mass drug administration to the at-risk population. Providing clean water to rural communities, improving sanitation, educating members of rural communities about the importance of hygiene, education about causes, pathology and preventive measures will lead to the control of schistosomiasis.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could influence this report.

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AUTHOR CONTRIBUTION

Conceptualization, designing: J.O.S.; data collection, participation in fieldwork: J.O.S., O.G.O.; data analysis; O.G.O.; interpreted the data, preparation of the first draft of the manuscript: J.O.S., O.G.O., B.M.S.; reviewing: O.G.O. All authors contributed to the development of the final manuscript and approved its submission.

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