URINARY SCHISTOSOMIASIS AMONG FARMERS IN DELTA NORTH AGRICULTURAL ZONE, DELTA STATE, NIGERIA

Supported by tetfund TERTIARY EDUCATION TRUST FUND

Antonia O. Enudi[1]*, Onyebiguwa P. G. Nmorsi[1], Andy O. Egwunyenga[1]
[1] Department of Animal and Environmental Biology, Faculty of Science, Delta State University, Abraka, Nigeria
* Corresponding author: Email: ebelenudi@hotmail.com; Telephone: +2348037141656

Received: June 09, 2024 Accepted: August 20, 2024

Abstract: This study aimed to assess the epidemiology of urinary schistosomiasis in freshwater swamp forest and lowland rainforest of Delta North agricultural zone. A cross-sectional study, conducted from July 2019 to December 2021, among 24,615 participants in some farming communities under treatment coverage detected infection using microscopy, microhaematuria and urine turbidity. Additionally, this study compared the efficacy of some diagnostic tests in diagnosing infections in 120 urine samples. Overall prevalence was 8.5% of which freshwater swamp forest had 7.3% and lowland rainforest 1.2%. Freshwater swamp forest participants had approximately three times the likelihood of developing schistosomiasis ($OR \approx 3$) compared to lowland rainforest, using microscopy, microhaematuria and urine turbidity as diagnostic indicators. Age group 0-9 years had the highest prevalence (14.8%) followed by 10-19 years (12.7%). Males had significantly higher prevalence than females ($P < 0.05$) and adolescent males 10-19 years had higher odds ratio than their female counterparts, compared to males and females 0-9 years because adolescent females were less likely to play in water due to puberty. Analysis of diagnostic tests showed that PCR had the highest prevalence (35.0%) with no false negative result. These findings showed that schistosomiasis is an indicator of socioeconomically disadvantaged areas, and requires sensitive monitoring tools to effectively identify hotbeds for strategic intervention.

Keywords: Delta North Agricultural Zone; diagnostic tests; farming; Schistosomiasis; *Schistosoma haematobium*.

Introduction

Schistosomiasis is a public health issue among the poor in tropical and subtropical countries in Africa, the Caribbean, South America and Asia. Close to 800 million people spread across 78 countries are at risk of the disease, with about 250 million people including 135 million school-aged children in need of preventive chemotherapy, while an estimated 280,000 deaths occur (Atalabi *et al*., 2018; Nelwan, 2019; WHO, 2022). Schistosomiasis, with a global burden of about 3.3 million disability-adjusted life years, is the second highest cause of morbidity following that of malaria (Boko *et al*., 2016; Nelwan, 2019), and is targeted for elimination as a public health problem by 2030 (WHO, 2022). The major schistosome parasites of public health importance in Nigeria are *Schistosoma haematobium* which is associated with urinary pathologies, and *S. mansoni* which affects the intestine and related organs (Nmorsi *et al*., 2007; Ojo *et al*., 2021; WHO, 2017). Infection and reinfection occur through human contact with open water infested with schistosome cercariae released by *Bulinus* and *Biomphalaria* snails. Disease transmission is enforced by lack of safe water and poor sanitation, which are commonplace in rural communities (Nelwan, 2019; WHO, 2022). Major water contact activities include farming, fishing, fetching water, bathing, swimming, laundry and dredging (Nwosu *et al.,* 2009; Ugbomoiko *et al*., 2010). High endemicity of urinary schistosomiasis, led to the launch of a schistosomiasis control program in 2004, at Abuator, Ndokwa East Local Government Area (LGA) of Delta State (The Carter Center Global Health News, 2005). Studies on schistosomiasis in Delta State include those by Nwabueze & Opara (2007), Ekwunife *et al*. (2009), Onyeneho *et al*. (2010), Ito & Egwunyenga (2015), Ito (2019).

Low disease transmission due to treatment has been reported in Nigeria however, reinfection is continuous because of unavoidable contact with schistosome infested water (Atalabi *et al*., 2018; Emukah *et al*., 2012; Kittur *et al*., 2017; Oyeyemi *et al*., 2020). With Nigeria ranked second in the world for open defecation, and an estimated 90% of the population lack basic water, sanitation and hygiene services (WASH) (FMWR *et al*., 2022), rural communities may serve as reservoirs of disease despite interventions (Ajayi *et al*., 2015; Ezeh *et al*., 2019; Oyeyemi *et al*., 2020).

With the federal and state government policy programmes to boost agriculture, more people are venturing into farming and fishing thereby, increasing the population at risk of developing schistosomiasis (Ajayi *et al*., 2015). This study assessed transmission of urinary schistosomiasis in freshwater swamp forest and lowland rainforest of Delta North Agricultural zone.

Materials and Methods

Study Area

This investigation was carried out in Delta North agricultural zone, which is divided in two major ecological zones, namely lowland rainforest and freshwater swamp forest (Balogun & Onokerhoraye, 2022). The study locations in freshwater swamp forest are Abuator (5º35'46.9N, 6º31'05.8E), Ise-Onukpor (5º35'19.9N, 6º34'21.8E), Onye-Uku camp (5º39'02.9N, 6º32'07.7E), Ibrede (5º33'29.9N, 6º23'31.4E) and Iyede-Ame (5º27'36.1N, 6º25'01.6E) in Ndokwa East LGA, in addition to Oko-Anala (6º05'49.1N, 6º42'36.1E) and Oko-Amakom (6º07'53.8N, 6º44'25.7E) in Oshimili South LGA. Ugbolu (6º18'39.8N, 6º41'26.7E) and Ebu (6º28'47.6N, 6º36'23.3E) in Oshimili North LGA are in lowland rainforest. The climate of Delta State is equatorial, with rainy and dry seasons, average annual rainfall range of 1,500 in the northern parts to 4,500 in the southern parts, and an average annual temperature range of 25ºC to 28ºC. The

study area experiences annual flooding of rain from September to November. Map of the study area is presented in Figure 1.

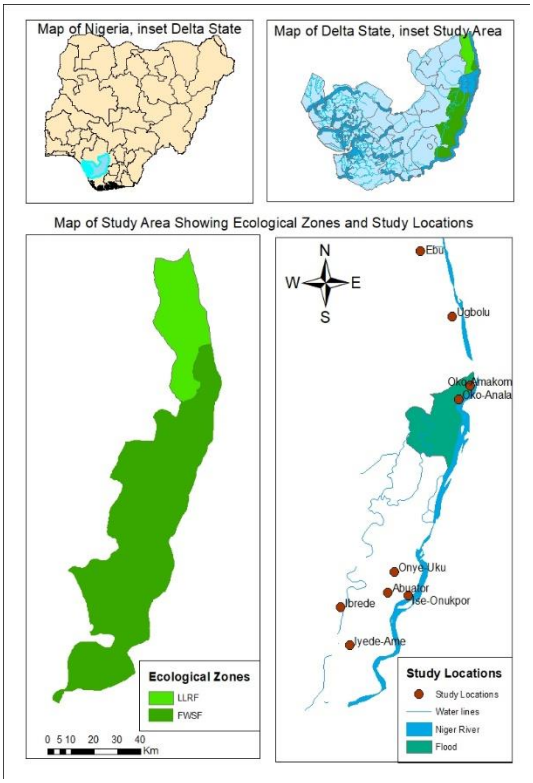

Figure 1. Map of Nigeria, Delta State and study locations

Study Procedure

The study was cross-sectional and conducted monthly from July 2019 to December 2021, excluding months of annual flooding when communities could not be accessed, and the Covid-19 pandemic lockdown when fieldwork was not carried out. The sample size was calculated using Slovin's formular. This study applied purposive sampling procedure to select communities. Delta North agricultural zone has nine LGAs of which the three LGAs bounded by the lower Niger River on the east, were selected. The northernmost LGA, Oshimili North, has a land size of 516 sq. km and a population of 161,259, while Oshimili South and Ndokwa East LGAs have a land size of 2,120 sq km and a population of 344,523 (MoEP, 2018). With the assistance of the Delta State Primary Health Care staff, nine communities in proximity to the Niger River or open water were randomly selected: two from lowland rainforest and seven from freshwater swamp forest. Preliminary visits to the communities were made, and permissions to carry out the study were obtained from the community leaders who also played a part in community mobilization (Dawaki *et al.*, 2015). Participants were made up of selected male and female volunteers from all age groups who were resident in the communities. Data were obtained through structured questionnaires administered on volunteers who gave their informed consent by signing or thumb printing the consent form (children gave consent by nodding their heads). A total of 24,615 volunteers who gave informed consent and produced urine samples, participated in the study, while the age categorization was adapted from the new WHO World Population Standard (Ahmad *et al.*, 2001) for comparison of prevalence across age groups.

Study Population

Subsistence farming of crops such as cassava, rice, yam and assorted vegetables is the major occupation of the people. Other economic activities include fishing, agro-processing, petty trading and hunting. In Ibrede, Oko, Ugbolu and Ebu, the population combine the use of pipe-borne water and open water, and have the added advantage of government healthcare services, while the population in Iyede-Ame, Abuator, Ise-Onukpor and Onye-Uku camp depend on lakes. Open defecation is practiced in all the communities however, some homes have toilet facilities. Additionally, the study communities are under annual treatment with praziquantel and children from 5 to 15 years are the major target populations (Emukah *et al*., 2012).

Sample Collection and Laboratory Analysis

Each volunteer received a 30 mL prelabelled screw-covered plastic container. Parents and caregivers assisted in the collection of urine samples of infants and younger children, while women under menstruation were excluded to avoid false positive haematuria. Samples collection took place from 10:00 am to 2:00 pm. Urine samples were first examined macroscopically for haematuria, clearness and turbidity, and then tested for microhaematuria and proteinuria using Medi-Test Combi 9®, Macherey-Nagel GmbH & Co. KG. The dipsticks were read about one minute after insertion into freshly passed urine, to avoid false positives and in accordance with the manufacturer's instruction. Samples were preserved in ice boxes and transported to the Animal and Environmental Biology laboratory at the Delta State University Abraka, for parasitological analysis that was carried out using the sedimentation technique in line with established protocol (Cheesbrough, 2009). Intensity of infection per 10 mL of urine was recorded as uninfected, 1-49 eggs as light and ≥50 eggs as heavy, according to the WHO categorization.

Urine samples preserved for PCR were transported to the Nigerian Institute of Medical Research (NIMR) Yaba, Lagos, for molecular investigations using the Dra1 121 bp DNA fragment. Samples were centrifuged for 10 minutes at 5,000 g after which, the supernatants were decanted. The pellets were washed thrice with 25 ml phosphate buffered saline (PBS) (0.8% NaCl, 2.7 mM KCl, 1.8 mM KH2PO4, 8 mM Na2HPO4, pH 7.4), spun with each washing and the supernatant discarded. Pellets were stored at -80^{o}C pending DNA extraction, which was carried out using NIMR extraction kit and followed established protocol (Ajayi *et al*., 2015; Akinwale *et al*., 2011).

Statistics

Data were subjected to statistical analysis using PAleontological STatistical Version 4.03 (PAST Øyvind Hammer, University of Oslo) to compute relationship between categorical variables. Odds ratio and Chi-squared test were calculated at 5% statistical significance and 95%

confidence interval. Also, MedCalc Software Version 22.013 (MedCalc Software, Belgium) was used to calculate Kappa's coefficient to test agreement between diagnostic tests, and to calculate sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios and accuracy. Microscopy result was the reference standard for evaluating diagnostic results.

Results

Prevalence of urinary schistosomiasis

A prevalence of 8.5% was encountered among 24,615 volunteers as shown in Table 1. Overall, males 13,291 had higher prevalence (5.5%) than females 11,324 (3.0%). Additionally, freshwater swamp forest volunteers had higher prevalence 1,808 (7.3%) than those in lowland rainforest 291 (1.2%). Water contact activities and open defecation were higher in the freshwater swamp than in lowland rainforest and the observed differences were statistically significant ($P < 0.05$). Knowledge of disease had significant relationship with forest, whereby 24.0% of freshwater swamp forest participants knew about schistosomiasis as against 7.6% in lowland rainforest.

This study highlighted the variations in the epidemiology of schistosomiasis in two ecological zones, which may be overlooked if prevalence is aggregated for the purpose of delivering interventions (Aagaard-Hansen & Chaignat, 2010). The lowland rainforest communities are semi urban, participants had more access to pipe borne water and sanitation. This forest has well-drained terrains, flowing water sources and hilly topography. The combination of these factors makes this agricultural zone less suitable for *Schistosoma* snail vectors and thus, less exposure of participants to parasites, compared to the waterlogged soil, with temporary and permanent water bodies, and rural villages in the freshwater swamp forest. .

The study area is under annual treatment with praziquantel nevertheless, the persistent water contacts for domestic, occupational and recreational activities, and poor sanitation especially in freshwater swamp forest could be major factors sustaining reinfection (Chisango *et al*., 2019; King & Bertsch, 2013; Senghor *et al*., 2016; N'Goran *et al*., 2001).

The overall low prevalence of 8.5% for urinary schistosomiasis is comparable with that of a previous study in Katsina State, Nigeria that recorded an overall prevalence of 8.68% (Atalabi et al., 2018) and with findings of Ekpo *et al.*(2013) that predicted a prevalence of < 10% for Delta State but contrasts with findings from a study on schistosomiasis in Tanzania that recorded an overall prevalence of 0.83% (Mazigo *et al.,* 2021). Our investigations indicated that other factors that predisposed participants to infection include age and sex, as reported in similar studies (Opara *et al.*, 2021; Mazigo *et al.,* 2021; Ismail *et al.,* 2014; Aagaard-Hansen & Chaignat, 2010).

Urinary schistosomiasis prevalence according to gender and age

The gender and age prevalence are shown in Table 2. Total prevalence across age groups reduced as age increased in freshwater swamp forest but was inconsistent in lowland rainforest. Although in both forests age group 0-9 years had the highest prevalence, freshwater swamp forest participants of 0-9 years had the highest overall prevalence of 17.0%. Gender prevalence in both forests had statistical significance ($P < 0.05$) and males had higher odds of developing disease (OR > 1.5).

This study observed that children of 0-9 years had the highest prevalence, followed by adolescents 10-19 years. Male children were predisposed to infection because they spent more time outdoors swimming and playing in water bodies. This finding could be compared to findings by Ismail *et al*. (2014) in a study at the White Nile River Basin, where children of 7-9 years old had the highest prevalence but contrasts with the highest prevalence observed among children ≥ 10 years in other studies (Ugbomoiko *et al.,* 2010; Ito, 2019; Nwosu *et al.,* 2006). A comparison of male and female odds ratio in age groups 0-9 and 10-19 showed that the odds of males 10-19 years developing disease relative to their female counterparts, was greater than the odds of males 0-9 years relative to their female counterparts. This could be because at adolescence, females have less water recreation than their male counterparts due to the developmental changes in their body. This finding however, differs from a study in Delta State (Ito, 2019) and in Osun State (Ojo *et al*., 2021), where female children had higher prevalence because they spent longer hours in water as a result of fetching water and other domestic responsibilities.

Prevalence of morbidity indicators

Morbidity indicators of urinary schistosomiasis are presented in Table 3. The freshwater swamp forest had higher prevalence of morbidity indicators than the lowland rainforest. It had 6.7% prevalence of light infections (< 50 eggs/10 mL urine) and 4.0% prevalence of heavy infections (≥ 50 eggs/10 mL urine), as well as higher likelihood of developing microhaematuria and urine turbidity than the lowland rainforest. Morbidity according to sex showed that in both forests, males had higher morbidity than females.

The observed intensity of infection, microhematuria and urine turbidity further confirmed that freshwater swamp forest participants are more vulnerable than those from lowland rainforest thus, indicating the usefulness of indirect morbidity indicators in diagnosing infection. These observations are comparable with previous studies on the efficacy of microhaematuria and urine turbidity as indicators of *S. haematobium* infection (Hassan *et al*., 2012; Houmsou *et al*., 2011; Morenikeji *et al*., 2014; Ojo *et al*., 2021). However, underestimation of prevalence using parasitological methods and indirect morbidity indicators have been reported in relation to the rhythmic release of schistosome eggs, age of human host, and treatment coverage (Lodh *et al*., 2014).

Analysis of diagnostic tests

Table 4 shows the relative detection rate of *S. haematobium* infection in 120 urine samples analysed using parasitological methods, indirect morbidity indicators and PCR. All *S. haematobium* egg positive cases showed Dra1 amplification bands hence, no case of false negative PCR. However, PCR detected some positive cases that were egg negative using microscopy. Conversely, some egg positive cases showed negative results using indirect morbidity indicators.

Freshwater swamp forest participants had higher odds of developing schistosomiasis using microhaematuria, sedimentation and PCR methods (*OR* > 2) compared to lowland rainforest participants, while urine turbidity and proteinuria had *OR* ≈1. However, only the PCR showed significant difference in parasite detection between the two forests (*P* = 0.01).

The diagnostic tools used for comparison in this study detected infection in both forests, however, PCR detected more infections in freshwater swamp forest which did not occur by chance, thus confirming this zone to be a high urinary schistosomiasis transmission zone and the need for sensitive tools for identification of hotbeds. The comparatively higher prevalence of schistosomiasis in freshwater swamp forest could be attributed to environmental factors, poor water and sanitation that keep the communities at constant risk of disease (Ismail *et al*., 2014; Ito, 2019; Nwosu *et al*., 2006; Ugbomoiko *et al*., 2010).

Table 1. Comparison of Urinary schistosomiasis associated factors in freshwater swamp forest and lowland rainforest

Variable	Freshwater Swamp Forest (%)	Lowland Rainforest (%)	Grand Total	*OR* (95% *CI*)	*P* Value
Number examined					
Males	9,235	4,056	13,291		
Females	7,756	3,568	11,324		
Total	16,991	7,624	24,615		
Number Infected					
Males	1,173 (12.7)	186 (4.6)	1,359 (5.5)	3.03 (2.58-3.55)	0.00
Females	635 (8.2)	105 (2.9)	740 (3.0)	2.94 (2.38-3.63)	0.00
Total	1,808 (10.6)	291 (3.8)	2,099 (8.5)	3.00 (2.64-3.41)	0.00
Overall Prevalence	7.3	1.2	8.5		
Age Group					
0-9	762 (17.0)	159 (9.2)	921 (14.8)	2.04 (1.70-2.44)	0.00
10-19	652 (16.1)	92 (5.2)	744 (12.7)	3.51 (2.80-4.40)	0.00
20-29	175 (8.0)	4 (0.4)	179 (5.7)	20.25 (7.53-55.01)	0.00
30-39	95 (4.9)	23 (3.1)	118 (4.4)	1.61 (1.01-2.56)	0.04
40-49	74 (5.1)	0 (0.0)	74 (3.4)		
50-59	36 (3.1)	4 (0.5)	40 (2.1)	5.98 (2.12-16.87)	0.00
60-69	8 (0.8)	9 (1.5)	17 (1.1)	0.55 (0.21-1.42)	0.22
≥70	6 (0.8)	0 (0.0)	6 (0.6)		
Water contact					
Yes	13,580 (79.9)	4,568 (59.9)	18,148	2.66 (2.51-2.83)	0.00
No	3,411 (20.1)	3,056 40.1)	6,467		
Toilet					
Pit	3,186 (18.8)	1,709 (22.4)	4,895	0.65 (0.61-0.69)	0.00
Water closet	1,263 (7.4)	693 (9.1)	1,956	0.80 (0.73-0.88)	0.00
Open defecation	12,542 (73.8)	5,222 (68.5)	17,764	1.30 (1.22-1.38)	0.00
Knowledge of Schistosomiasis					
No	12,906 (76.0)	7,046 (92.4)	19,952	3.86 (3.52-4.23)	0.00
Yes	4,085 (24.0)	578 (7.6)	4,663		

Table 2. Prevalence of Urinary Schistosomiasis by Age and Sex in Freshwater Swamp Forest and Lowland Rainforest

Variable	No. Examined			No. Infected			Odds Ratio	*P* Value
	Male	Female	Total	Male (%)	Female (%)	Total (%)	(95% *CI*)	
Freshwater Swamp Forest	9,235	7,756	16,991	1173 (12.7)	635 (8.2)	1808 (10.6)	1.63 (1.47-1.81)	0.00
Age groups								
0-9	2,478	1,999	4,477	463 (18.7)	299 (15.0)	762 (17.0)	1.31 (1.11-1.53)	0.00
10-19	2,182	1,879	4,061	417 (19.1)	235 (12.5)	652 (16.1)	1.65 (1.39-1.97)	0.00
20-29	1,198	991	2,189	112 (9.3)	63 (6.4)	175 (8.0)	1.52 (1.10-2.09)	0.01
30-39	1,085	859	1,944	79 (7.3)	16 (1.9)	95 (4.9)	4.14 (2.40-7.14)	0.00
40-49	765	694	1,459	61 (8.0)	13 (1.9)	74 (5.1)	4.54 (2.47-8.34)	0.00
50-59	616	558	1,174	33 (5.4)	3 (0.5)	36 (3.1)	10.47 (3.19-34.34)	0.00
60-69	535	440	975	8 (1.5)	0 (0.0)	8 (0.8)		0.01
≥ 70	376	336	712	0 (0.0)	6 (1.8)	6 (0.8)		0.01
Lowland Rainforest	4,056	3,568	7,624	186 (4.6)	105 (2.9)	291 (3.8)	1.59 (1.24-2.02)	0.00
Age groups								
0-9	915	822	1,737	103 (11.3)	56 (6.8)	159 (9.2)	1.74 (1.23-2.44)	0.00
10-19	975	807	1,782	63 (6.5)	29 (3.6)	92 (5.2)	1.85 (1.18-2.91)	0.01
20-29	513	428	941	0 (0.0)	4 (0.9)	4 (0.4)	0.09 (0.00-1.71)	0.11
30-39	380	364	744	8 (2.1)	15 (4.1)	23 (3.1)	0.50 (0.21-1.19)	0.12
40-49	385	354	739	0 (0.0)	0 (0.0)	0 (0.0)		
50-59	406	354	760	4 (1.0)	0 (0.0)	4 (0.5)	7.93 (0.43-47.75)	0,17
60-69	307	296	603	8 (2.6)	1 (0.3)	9 (1.5)	7.89 (0.98-63.50)	0.05
≥ 70	175	143	318	0 (0.0)	0 (0.0)	0 (0.0)		

Table 3. Morbidity indicators of urinary schistosomiasis according sex in freshwater swamp forest and lowland rainforest

Variable	Freshwater Swamp Forest			Lowland Rainforest			Odds Ratio (95% *CI*)	*P* Value
	Male (%) n=9,235	Female (%) n=7,756	Total (%) n=16,991	Male (%) n=4,056	Female (%) n=3,568	Total (%) N=7,624		
Intensity								
< 50 eggs/10 mL urine	729 (7.9)	404 (5.2)	1133 (6.7)	113 (2.8)	58 (1.6)	171 (2.2)	3.11 (2.65-3.67)	0.00
≥ 50 eggs/10 mL urine	444 (4.8)	231 (3.0)	675 (4.0)	73 (1.8)	47 (1.3)	120 (1.6)	2.59 (2.13-3.15)	0.00
Microhaematuria								
Light (+)	300 (3.2)	170 (2.2)	470 (2.8)	31 (0.8)	21 (0.6)	52 (0.7)		
Moderate (++)	459 (5.0)	242 (3.1)	701 (4.1)	74 (1.8)	43 (1.2)	117 (1.5)		
Heavy (+++)	440 (4.8)	249 (3.2)	689 (4.1)	73 (1.8)	39 (1.1)	112 (1.5)		
Total	1,199 (13.0)	661 (8.5)	1,860 (10.9)	178 (4.4)	103 (2.9)	281 (3.7)	3.21 (2.82-3.65)	0.00
Urine turbidity								
Cloudy	874 (9.5)	507 (6.5)	1381 (8.1)	135 (3.3)	86 (2.4)	221 (2.9)		
Cloudy and bloody	170 (1.8)	115 (1.5)	285 (1.7)	41 (1.0)	15 (0.4)	56 (0.7)		
Total	1,044 (11.3)	622 (8.0)	1,666 (9.8)	176 (4.3)	101 (2.8)	277 (3.6)	2.88 (2.53-3.28)	0.00

Table 4. Analysis of diagnostic tests across ecological zones

Variable	Total (%)	FWSF (%)	LLRF (%)	*OR* (95% *CI*)	*P* Value
No. samples		66	54		
Urine turbidity	24 (20.0)	13 (19.7)	11 (20.4)	0.96 (0.39-2.35)	0.93
Microhaematuria	18 (15.0)	13 (19.7)	5 (9.3)	2.40 (0.80-7.24)	0.12
Proteinuria	27 (22.5)	15 (22.7)	12 (22.2)	1.03 (0.43-2.44)	0.95
Sedimentation	20 (16.7)	15 (22.7)	5 (9.3)	2.88 (0.97-8.53)	0.06
Dra1 PCR	42 (35.0)	30 (45.5)	12 (22.2)	2.92 (1.31-6.52)	0.01

FWSF: Freshwater Swamp Forest, LLRF: Lowland Rainforest, *OR*: Odds ratio.

Table 5. Diagnostic tests agreement statistics

Tests	Kappa coefficient	95% *CI*	Level of agreement
PCR vs UT	0.43	0.26 to 0.60	Moderate
PCR vs MH	0.41	0.25 to 0.57	Moderate
PCR vs PU	0.34	0.17 to 0.52	Fair
PCR vs Sed	0.54	0.39 to 0.70	Moderate
Sed vs UT	0.56	0.36 to 0.75	Moderate
Sed vs MH	0.69	0.51 to 0.87	Substantial
Sed vs PU	0.39	0.19 to 0.60	Fair
UT vs MH	0.83	0.70 to 0.96	Almost perfect
UT vs PU	0.73	0.58 to 0.88	Substantial
MH vs PU	0.65	0.48 to 0.82	Substantial

Sed: Sedimentation; UT: Urine Turbidity; MH: Microhematuria; PU: Proteinuria.

Table 6. Estimation of sensitivity, specificity, likelihood ratios, disease prevalence, predictive values and accuracy for diagnostic schistosomiasis

Diagnostic test	Sensitivity (%)	Specificity (%)	Positive Likelihood Ratio	Negative Likelihood Ratio	Disease Prev (%)	PPV (%)	NPV (%)	Accuracy (%)
Sed	47.62	100.00		0.52	16.7	100.00	90.52	91.27
(95% *CI*)	(32.00-63.58)	(95.38-100.00)		(0.39-0.75)			(87.73-92.72)	(84.72-95.65)
PCR	100.00	100.00		0.00	35.0	100.00	100.00	100.00
(95% *CI*)	(91.59-100.00)	(95.38-100.00)						(96.97-100.00)
MH	40.00	97.50	16.00	0.62	13.3	71.11	91.35	89.84
(95% *CI*)	(24.86 - 56.67)	(91.26- 99.70)	(3.87- 66.20)	(0.48- 0.79)		(37.29- 91.06)	(89.11-93.17)	(82.99-94.60)
UT	45.24	93.59	7.06	0.59	15.8	57.03	90.09	85.94
(95% *CI*)	(29.85- 61.33)	(85.67-97.89)	(2.84-17.55)	(0.44-0.77)		(34.80-76.75)	(87.28-92.33)	(78.41-91.61)
PU	42.86	88.46	3.71	0.65	15.0	39.59	89.77	81.62
(95% *CI*)	(27.72-59.04)	(79.22-94.59)	(1.83-7.53)	(0.49-0.85)		(24.43-57.06)	(86.96-92.02)	(73.52-88.10)

Sed: Sedimentation method; MH: Microhematuria; UT: Urine Turbidity; PU: Proteinuria; *CI*: Confidence Interval; PPV: Positive Predictive Value; NPV: Negative Predictive Prev: Prevalence.

Measurement of agreement

At Table 5 is the comparison of diagnostic tests. Kappa value κ was used to measure the level of agreement between the diagnostic methods given the differences observed in the number of positive cases detected. The strength of agreement was categorized as: 0.00-0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, 0.81-1.00 as almost perfect McHugh (2012). PCR had the strongest agreement with sedimentation method (0.54) and least with proteinuria (0.34), while urine turbidity had an almost perfect agreement with microhaematuria (0.83).

This study observed that PCR and sedimentation method had the closest agreement confirming that presence of eggs was more indicative of infection than positive cases of microhaematuria, proteinuria and urine turbidity (Lodh *et al.,* 2014). Likewise, sedimentation method agreed the most with microhaematuria thus, the application of microhaematuria for estimating *S. haematobium* infection (Emukah *et al.,* 2012).

Sensitivity, specificity, likelihood ratio, predictive value and accuracy of diagnostic tests

In Table 6, PCR identified more positive cases compared to other technique thus, a sensitivity, specificity, predictive values and accuracy of 100.00%. This was followed by sedimentation method with a sensitivity of 47.62% (95% CI: 32.00%-63.58%) but high specificity, predictive values and accuracy. Microhematuria had the least sensitivity, while proteinuria had the least specificity and accuracy.

From the diagnostic tests performance, PCR proved to be a more sensitive tool for detecting *S. haematobium* infections, followed by microscopy. This result is also in consonance with studies on the sensitivity and specificity of PCR in detecting *Schistosoma* infection in low disease transmission and in treatment settings (Siqueira *et al.*, 2015; Lodh *et al.,* 2014). The false negative cases detected by indirect morbidity indicators might be due to the absence of pathological changes in the bladder because of treatment, while the false positive cases might be due to infections other than that of *S. haematobium* (Houmsou *et al.*, 2011).

Conclusion

This study observed that urinary schistosomiasis still persists despite decades of treatment. The overall prevalence was

low, with geographical variations due to socioeconomic factors, variations in gender and age prevalence largely due to behaviour, and variations using different diagnostic tools. This study therefore provides information that is useful for advocacy in agricultural zones, towards improving access to clean water and adequate sanitation, and for disease monitoring using sensitive diagnostic tools, in order to identify foci for strategic delivery of interventions towards achieving the 2030 elimination goal.

Ethical consideration

The Delta State University Ethical Review Committee (REC/FOS/17/02) and the Ministry of Health Research and Ethics Committee (HM/596/T^2/47) gave ethical approval for this study to be carried out. The Delta State Primary Health Care Agency gave approval for the use of their facilities in the study locations and community leaders gave permissions for the study to be carried out in their communities.

Acknowledgement

We appreciate the kings, village chiefs, leaders and study volunteers for their consent, support and participation. We equally appreciate the Delta State Primary Healthcare Development Agency, Chidi Njoku of The Carter Center for his assistance and Dr. Vincent Pam Gyang of the Nigerian Institute of Medical Research (NIMR) Yaba, Lagos, for giving us technical assistance. We are grateful to all those that contributed towards the success of this study.

Disclosure of Conflict of Interest

The authors declare that they have no competing interests.

References

Aagaard-Hansen J & Chaignat CL 2010. Neglected tropical diseases: equity and social determinants In: Equity, Social Determinants, and Public Health Programmes. Geneva: World Health Organization, pp. 135 - 157.

Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R & Inoue M 2001. Age Standardization of Rates: A New WHO Standard. GPE. Discussion Paper Series: No 31, pp. 10 – 12.

Ajayi JB, Sam-Wobo SO & Agbeyangi AO 2015. Prevalence of urinary schistosomiasis in part of Ogun State, Nigeria. *J. Nat. Sci Res*., 5(5): 62 – 68.

Akinwale OP, Akpunonu V, Ajayi MB, Akande DO, Adeleke MA, Gyang P, Adebayo M & Dike A 2011. Urinary schistosomiasis transmission in Epe, an urban community of Southwest Nigeria. *Trop. Parasitol*., 1(2): 99 - 103.

Atalabi TE, Adoh SD & Eze KM 2018. The current epidemiological status of urogenital schistosomiasis among primary school pupils in Katsina State, Nigeria: An imperative for a scale up of water and sanitation initiative and mass administration of medicines with Praziquantel. *PLoS Negl. Trop. Dis*., 12(7): e0006636.

Balogun VS & Onokerhoraye AG 2022. Climate change vulnerability mapping across ecological zones in Delta State, Niger Delta Region of Nigeria. *Climate Services*. 27: 100304.

Boko PM, Ibikounle M, Onzo-Aboki A, Tougoue JJ, Sissinto Y, Batcho W, Kinde-Gazard D & Kabore A 2016. Schistosomiasis and soil transmitted helminths distribution in Benin: a baseline prevalence survey in 30 districts. *PLoS One*, 11(9): e0162798.

Cheesbrough M 2009. District Laboratory Practice in Tropical Countries. Part 1 2nd edn. Cambridge University Press, Cambridge, pp. 236-239.

Chisango T, Ndlovu B, Vengesai A, Nhidza AF, Sibanda EP, Zhou DT, Mutapi F, & Mduluza T 2019. Benefits of annual chemotherapeutic control of schistosomiasis on the development of protective immunity. *BMC Infect. Dis*., 19(1): 219.

Dawaki S, Al-Mekhlafi HM, Ithoi I, Ibrahim J, Abdulsalam AM, Ahmed A, Sady H, Nasr NA & Atroosh WM 2015. The Menace of Schistosomiasis in Nigeria: Knowledge, Attitude, and Practices Regarding Schistosomiasis among Rural Communities in Kano State. *PLoS ONE* 10(11): e0143667.

Ekpo UF, Hürlimann E, Schur N, Oluwole AS, Abe EM, Mafe MA, Nebe OJ, Isiyaku S, Olamiju F, Kadiri M, Poopola TO, Braide EI, Saka Y, Mafiana CF, Kristensen TK, Utzinger J & Vounatsou P 2013. Mapping and prediction of schistosomiasis in Nigeria using compiled survey data and Bayesian geospatial modelling. *Geospat. Health*., 7(2): 355 – 366.

Ekwunife C, Agbor V, Ozumba A, Eneanya C & Ukaga C 2009. Prevalence of urinary schistosomiasis in Iyede-Ame community and environ in Ndokwa East Local Government Area, Delta State, Nigeria. *Niger. J. Parasitol*., 30(1): 10 - 43.

Emukah E, Gutman J, Eguagie J, Miri ES, Yinkore P, Okocha N, Jibunor V, Obiageli N, Ikenna NA & Richards FO 2012. Urine heme dipsticks are useful in monitoring the impact of Praziquantel treatment on *Schistosoma haematobium* in sentinel communities of Delta State, Nigeria. *Acta Trop*., 122(1): 126 – 131.

Ezeh CO, Onyekwelu KC, Akinwale OP, Shan L & Wei H 2019. Urinary schistosomiasis in Nigeria: a 50 year review of prevalence, distribution and disease burden. *Parasite*, 26: 19–.

FMWR, Government of Nigeria, NBS & UNICEF 2022. Water, Sanitation and Hygiene: National Outcome Routine Mapping (WASHNORM) 2021: A Report of Findings. FCT Abuja Nigeria, p. 30.

Hassan A, Ntiaidem U, Morenikeji O, Nwuba R, Anumudu C, Adejuwon S, Salawu O, Jegede A & Odaibo A 2012. Urine turbidity and microhaematuria as rapid assessment indicators for *Schistosoma haematobium* infection among school children in endemic areas. *Am. J. Infect. Dis*., 8(1): 60 - 64.

Houmsou RS, Kela SL & Suleiman M 2011. Performance of microhaematuria and proteinuria as measured by urine reagent strips in estimating intensity and prevalence of Schistosoma haematobium infection in Nigeria. *Asian Pac. J. Trop. Med*., 4(12): 997 – 1000.

Ismail HAHA, Hong ST, Babiker ATEB, Hassan RMAE, Sulaiman MA, Jeong HG, Kong WH, Lee SH, Cho HI, Nam HS, Oh CH & Lee YH 2014. Prevalence, risk factors, and clinical manifestations of schistosomiasis among school children in the White Nile River basin, Sudan. *Parasit. Vectors*., 7(1): 478.

Ito EE & Egwunyenga AO 2015. Schistosomiasis: The aftermath of 2012 floods in Delta State, Southern Nigeria. *Int. Medical J*., 22(4): 218 – 223.

Ito EE 2019. Hyper-endemicity of urinary schistosomiasis in two communities in lower Niger Delta, southern Nigeria. *Niger. J. Parasitol*., 40(1): 76 - 81.

King CH & Bertsch D 2013. Meta-analysis of urine heme dipstick diagnosis of *Schistosoma haematobium* infection, including low-prevalence and previously-treated populations. *PLoS Negl. Trop. Dis*., 7(9): e2431.

Kittur N, Binder S, Campbell CH, King CH, Kinung'hi S, Olsen A, Magnussen P, & Colley DG 2017. Defining persistent hotspots: areas that fail to decrease meaningfully in prevalence after multiple years of mass drug administration with praziquantel for control of schistosomiasis. *Am. J. Trop. Med. Hyg*., 97(6): 1810 – 1817.

Lodh N, Naples JM, Bosompem KM, Quartey J & Shiff C 2014. Detection of parasite-specific DNA in urine sediment obtained by filtration differentiates between single and mixed infections of *Schistosoma mansoni* and *S. haematobium* from endemic areas in Ghana. *PLoS One*, 9(3): e91144.

Mazigo HD, Uisso C, Kazyoba P, Nshala A & Mwingira U 2021. Prevalence, infection intensity and geographical distribution of schistosomiasis among pre-school and school aged children in villages surrounding Lake Nyasa, Tanzania. *Sci. Rep*., 11(1): 295.

McHugh ML 2012. Interrater reliability: the kappa statistic. *Biochemia Medica* (Zagreb) 22(3): 276 - 282.

MoEP 2018. Delta State 2018 statistical yearbook. Central Office of Research and Statistics, Ministry of Economic Planning, Asaba, Delta State

Morenikeji OA, Quazim J, Omoregie C, Hassan AA, Nwuba RI, Anumudu CI, Adejuwon S, Salawu O, Jegede A & Odaibo A 2014. A cross-sectional study on urogenital schistosomiasis in children; haematuria and proteinuria as diagnostic indicators in an endemic rural area of Nigeria. *Afr. Health Sci*., 14(2): 390 - 396.

Nelwan ML 2019. Schistosomiasis: life cycle, diagnosis, and control. *Curr Ther Res Clin Exp*., 91: 5 - 9.

N'Goran EK, Utzinger J, N'Guessan AN, Müller I, Zamblé K, Lohourignon KL, Traoré M, Sosthène BA, Lengeler C &Tanner M 2001. Reinfection with *Schistosoma haematobium* following school-based chemotherapy with praziquantel in four highly endemic villages in Côte d'Ivoire. *Trop. Med. Int. Health*., 6(10): 817 - 825.

Nmorsi OPG, Ukwandu NCD, Ogoinja S, Blackie HOT & Odike M a C 2007. Urinary tract pathology in some *Schistosoma haematobium* infected Nigerians. *Afr. J. Biotechnol*., 6(2): 123 – 127.

Nwabueze AA & Opara KN 2007. Outbreak of urinary schistosomiasis among school children in riverine communities of Delta State, Nigeria: impact of road and bridge construction. *J. Med. Sci*., 7: 572 - 578.

Nwosu D, Anosike J, Nwoke B & Uwaezouke J 2009. Epidemiological assessment of vesical schistosomiasis in Bende Local Government area of Abia State, Nigeria. *JASEM*, 10(2): 55 - 60.

Ojo JA, Adedokun SA, Akindele AA, Olorunfemi AB, Otutu OA, Ojurongbe TA, Thomas BN, Velavan TP & Ojurongbe O 2021. Prevalence of urogenital and intestinal schistosomiasis among school children in South-west Nigeria. *PLoS Negl. Trop. Dis*., 15(7): e0009628.

Onyeneho NG, Yinkore P, Egwuage J & Emukah E 2010. Perceptions, attitudes and practices on schistosomiasis in Delta State, Nigeria. *Tanzan. J. Health Res*., 12(4): 287 - 298.

Opara KN, Wilson EU, Yaro CA, Alkazmi L, Udoidung NI, Chikezie FM, Bassey BE & Batiha GE 2021. Prevalence, Risk Factors, and Coinfection of Urogenital Schistosomiasis and Soil-Transmitted Helminthiasis among Primary School Children in Biase, Southern Nigeria. *J. Parasitol. Res*., 2021: 1 – 12.

Oyeyemi OT, De Jesus Jeremias W & Grenfell RFQ 2020. Schistosomiasis in Nigeria: gleaning from the past to improve current efforts towards control. *One Health*, 11: 100183.

Senghor B, Diaw OT, Doucouré S, Seye M, Diallo A, Talla I, Bâ CT & Sokhna C 2016. Impact of annual praziquantel treatment on urogenital schistosomiasis in a seasonal transmission focus in central Senegal. *PLoS Negl. Trop. Dis*., 10(3): e0004557.

Siqueira LM, Gomes LI, Oliveira E, Oliveira ER, Oliveira ÁA, Enk MJ, Carneiro NF, Rabello A & Coelho PM 2015. Evaluation of parasitological and molecular techniques for the diagnosis and assessment of cure of schistosomiasis mansoni in a low transmission area. *Mem. Inst. Oswaldo Cruz*., 110(2): 209 – 214.

The Carter Center Global Health News 2005. Delta State, Nigeria, launches schistosomiasis program. *Eye of the Eagle*, 6(1): 11.

Ugbomoiko US, Ofoezie IE, Okoye IC & Heukelbach J 2010. Factors associated with urinary schistosomiasis in two peri-urban communities in south–western Nigeria. *Ann. Trop. Med. Parasitol*., 104(5): 409 – 419.

WHO 2017. Integrating Neglected Tropical Diseases into Global Health and Development: Fourth WHO Report on Neglected Tropical Diseases. Geneva: World Health Organization, pp. 240-247.

WHO 2022. Guideline on Control and Elimination of Human Schistosomiasis. Geneva: World Health Organization.