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Article

Evaluation of the Endemicity and Diagnostic Markers of Urogenital Schistosomiasis Among the “Seldom-Heard Groups in Atiba LGA, Oyo State, Nigeria

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Abstract

Background: Urogenital schistosomiasis (UGS) remains a major public health concern in Nigeria, particularly in peri-urban and rural communities with poor sanitation and frequent contact with natural water bodies. This study assessed the prevalence, intensity, and age-gender distribution of *Schistosoma haematobium* infection and associated urinary abnormalities across five under-represented communities in Atiba LGA, Oyo State, Nigeria. **Methods:** A cross-sectional community-based survey involved 239 residents of Alagbede, Alagbon, Asamu, Ojala, and Ile Titun. Urine samples were microscopically examined for *S. haematobium* eggs, tested for haematuria, proteinuria, and leukocyturia, and infection intensity classified as light (<50 eggs/10 mL) or heavy (≥50 eggs/10 mL) based on WHO egg count thresholds. **Results:** An overall UGS prevalence of 56.9% was recorded, with the highest proportions observed in the Alagbede community (69.6%). The overall mean intensity of infection was 64.04 ± 118.81 eggs/10 mL of urine. Females had a slightly higher overall prevalence (58.9%) compared to males (55.7%) ($p > 0.05$). Across all communities, the 10–17-year age group had the highest prevalence (78.7%) of infection and mean intensity of infection (87.62 ± 163.29 eggs/10 mL), indicating infection to be age-specific. Urinary abnormalities, including haematuria (42.3%), proteinuria (41.8%), and leukocyturia (22.6%), were commonly detected among infected individuals, particularly those with heavy infection intensities. *Bulinus truncatus* was found only in Asamu, where all the collected snails (100%) shed furcocercous cercariae. **Conclusion:** This study revealed that UGS remains a serious public health concern in the study area, with school-aged children bearing the greatest burden. The associated urinary abnormalities observed underline the potential long-term health consequences of untreated infections. These findings reinforce the urgent need for sustained and integrated control measures, including improved access to clean water and sanitation, community-based health education, and regular preventive chemotherapy. Strengthening these interventions in endemic communities is key to reducing transmission, safeguarding child health, and moving closer to the elimination of schistosomiasis. This study provides novel epidemiological data on UGS in Atiba LGA, Oyo State, filling a knowledge gap by documenting prevalence, infection intensity, and associated urinary abnormalities in the communities.

Keywords: urogenital schistosomiasis; *Schistosoma haematobium*; prevalence; infection intensity; urinary abnormalities; school-aged children

1. Summary

Nigeria is endemic for schistosomiasis, and public health officials have been conducting mass drug administration (MDA) with praziquantel targeting the school-aged children regularly and at-risk adults where prevalence is high. This study was conducted between September and December 2024 in five communities of Atiba LGA, Oyo State. These communities were selected because they are located near snail-infested freshwater bodies, rely heavily on untreated water from the Ikere

George Dam, and engage in frequent water contact activities such as fishing, bathing, laundry, and irrigation, making them prone to schistosomiasis exposure. A total of 239 participants from Alagbede, Alagbon, Asamu, Ojala, and Ile Titun provided urine samples for testing. Urogenital schistosomiasis was detected using the urine filtration technique with microscopy, while haematuria, proteinuria, and leukocyturia were assessed with urinalysis strips. Overall prevalence was 56.9%, with a mean intensity of 64.04 ± 118.81 eggs/10 mL and heavy intensity at 28.9%. Haematuria, proteinuria, and leukocyturia prevalence were 42.3%, 41.7%, and 22.6% respectively. *Bulinus truncatus* was recorded in Asamu but absent in the other communities, and 100% of those collected shed furcocercous cercariae. Findings indicate no significant progress in eliminating schistosomiasis despite mass drug administration, emphasizing the urgent need for targeted, community-level interventions to control and eventually eliminate the disease.

2. Introduction

Schistosomiasis is a neglected tropical disease of major global concern, with an estimated 240 million people requiring preventive treatment and over 700 million living in endemic regions, predominantly across 76 countries in sub-Saharan Africa (SSA [1,2]. Nigeria bears the highest global burden, with about 25 million people affected, mostly by urogenital schistosomiasis (UGS) caused by *Schistosoma haematobium* [3–5]. Transmission occurs when humans come into contact with freshwater containing cercariae shed by infected snails, primarily *Bulinus* spp., as the intermediate host [6]. Following skin penetration, cercariae transform into schistosomulae, migrate through the body, and mature into adult worms in the venous plexuses, where they release eggs. While some eggs are excreted, many become lodged in tissues, provoking granulomatous inflammation, fibrosis, and haematuria [7,8]. The endemicity of schistosomiasis is associated with the presence of suitable intermediate host snails, with *Biomphalaria* spp. serving as intermediate hosts for *Schistosoma mansoni* and *Bulinus* spp. for *S. haematobium* [9,10].

In SSA, *S. haematobium* and *S. mansoni* account for most human cases, with Nigeria consistently reporting the heaviest burden [11,12]. Despite multiple rounds of mass drug administration (MDA) with praziquantel, UGS persists in many disease hotspots. Contributing factors include poverty, inadequate health infrastructure, and continued dependence on unsafe water sources [13,14]. In rural areas, domestic and occupational activities such as laundry, bathing, irrigation farming, and fishing increase human–water contact, thereby sustaining transmission [15].

Schistosomiasis rarely causes death directly but is responsible for chronic morbidity, including anaemia, malnutrition, and impaired productivity [16]. Chronic UGS is associated with haematuria, hydronephrosis, bladder fibrosis, increased risk of squamous cell carcinoma, and female genital schistosomiasis [17,18]. In children, the disease impairs growth, school performance, and long-term health outcomes [19]. These consequences emphasize the public health importance of schistosomiasis eradication to safeguard health and enhance the well-being of affected communities.

Diagnosis of UGS relies primarily on microscopic detection of parasite eggs in urine, typically through urine filtration or centrifugation [20,21]. A single 10 mL urine sample can detect infections with light-to-high intensity, but sensitivity is limited in light infections (<50 eggs/10 mL). Several urinary tract abnormalities are associated with *Schistosoma haematobium* infections, notably haematuria (presence of blood in urine), proteinuria (presence of protein in urine), and leukocyturia (presence of white blood cells in urine) [22].

Haematuria is thought to result from the mechanical damage caused by the terminal spine of *S. haematobium* ova embedding in the bladder walls, creating lesions and microbleeds that persist even after cessation of egg excretion [23–25]. Proteinuria has been associated with glomerular injury mediated by immune complex deposition or with the extent of bladder and ureteral lesions caused by egg deposition. Leukocyturia is indicative of inflammatory responses to trapped eggs within urinary tissues [26,27]. Urinary abnormalities such as haematuria, proteinuria, and leukocyturia detected with reagent strips serve as useful indirect diagnostic markers [22]. However, these indicators may yield false positives, and their accuracy diminishes in low-intensity infections [28,29].

Despite these limitations, reagent strips remain valuable for rapid screening, especially in resource-limited settings [30,31].

Gender differences in schistosomiasis prevalence and intensity have been inconsistently reported across SSA [32]. In some settings, males show a higher prevalence due to fishing, swimming, and recreational water contact [33–35]. In others, females are disproportionately affected, reflecting their frequent engagement in domestic water-related tasks such as laundry, bathing, and fetching water [32,36]. Biological factors, including hormonal influences on immune regulation, may further modulate susceptibility [37]. Thus, gender disparities reflect a complex interplay between behavioural exposure and biological responses.

Globally, schistosomiasis control has gained renewed momentum under the WHO's 2021–2030 neglected tropical diseases (NTD) roadmap, which sets elimination of schistosomiasis as a public health problem, defined as <1% heavy-intensity infections in all endemic countries by 2030 [38]. Achieving this ambitious goal requires sustained MDA, strengthened health systems, snail control, provision of safe water, and deployment of improved diagnostics and surveillance tools.

Despite progress, many underserved Nigerian communities remain unstudied, with little or no data to guide interventions. Oyo State is one of such regions, where large earth dams used for irrigation, fishing, and livestock watering create conditions favourable for transmission. While studies have been conducted in other parts of the state, several rural communities remain unmapped for their endemic status, limiting evidence-based control planning [33,39,40]. Updated epidemiological data from such areas are essential for national elimination targets. Therefore, this study aimed to (i) determine the prevalence and intensity of *S. haematobium* infection in underserved communities of Atiba Local Government Area, Oyo State, Nigeria, (ii) evaluate the diagnostic performance of urine reagent strips and urine filtration technique with microscopy (iii) assess the distribution of freshwater snails across water bodies; and provide praziquantel treatment to community members.

3. Methods

3.1. Study Area

The study was conducted in five selected rural communities in Atiba Local Government Area, Oyo State, Nigeria. Oyo State is in the south-western part of Nigeria, which consists of 33 Local Government Areas, with its capital in Ibadan. The total land area of Oyo state is approximately 28,454 square kilometres, with a population of 7,840,900 in 2016. Oyo State is bordered to the north by Kwara State, to the east by Osun State, and to the southwest by Ogun State and the Republic of Benin. The study communities are Alagbede, Asamu, Ojala, Ile-Titun and Alagbon, and they are located in the rain forest zone of Oyo State. And each community is between 88.8km and 94.6km from Ibadan (Table 1). Alagbede is situated between Latitude 8°12'20.26"N, and Longitude 3°46'52.34"E, Asamu (Latitude 8°13'46.08"N, Longitude 3°47'15.47"E), Ojala (Latitude 8°12'4.70"N, Longitude 3°48'6.25"E), Ile-Titun (Latitude 8°11'22.32"N, Longitude 3°48'23.55"E), and Alagbon located between (Latitude 8°10'40.59"N, Longitude 3°47'21.53"E) (Figure 1). These communities are all in a region with a local climate of dry season (November–March) and rainy season (April–October). They rely on a major dam that serves as their primary source of daily water for household use and other activities such as fishing and farming. The communities lack basic amenities, with few schools and no health care facilities. Hospitals/clinics are rarely accessible to them since they are very far, and roads are in a deplorable condition. The communities are populated with houses without efficient toilet facilities, forcing the occupants to visit bushes, refuse dumps, and open gutters for defecation. Few houses in the communities have pit latrines. There is no drainage system, and the communities often lack effective waste management systems.

The people of Atiba speak the Yoruba language; however, non-indigenes from other parts of Nigeria, such as Hausa, Ibira, Idoma, Tiv, and Benue, migrate to the region for commercial reasons.

The agricultural sector in Atiba LGA is vibrant, cultivating significant amounts of crops like rice, pepper, cassava, cocoa and wheat.

3.2. Study Population, Design and Sample Size

A community-based cross-sectional study was conducted in the study area. Urine samples were collected from 239 volunteering participants between the ages of 5 and 90 years. The volunteering participants were gathered at the community centres located in each of the communities, where the sample collection was held. These community centres were chosen due to their secure environments, ensuring the safety and well-being of participants throughout the study. The proximity of the centres to the sample collection locations also provided convenient access for participants, reducing travel time and minimizing disruptions to their daily lives.

3.3. Data Collection

Participants were recruited from the study communities based on their willingness to participate. Inclusion criteria required that individuals be residents of the communities and present on the day of sampling. Before enrolment, each participant (or parent/guardian for minors) was provided with an informed consent form, which was explained in the local language, and only those who signed (or assented) were included in the study. Individuals who were not residents of the study communities and those who declined to provide informed consent/assent were excluded from the study. A standardized questionnaire was administered to collect demographic information, including age, sex, and community of residence. This allowed stratification of infection data according to demographic variables. Participants' confidentiality was ensured by anonymizing data and using coded identifiers, with access restricted to the research team. In addition, individuals who tested positive for *Schistosoma haematobium* were administered praziquantel treatment according to national guidelines. This study was conducted between September and December 2024 in five communities of the Atiba Local Government Area (LGA), Oyo State, Nigeria. The communities are known to be endemic for UGS, and although mass drug administration (MDA) campaigns were conducted two years before this study, the communities remain underserved due to poor road networks and security challenges.

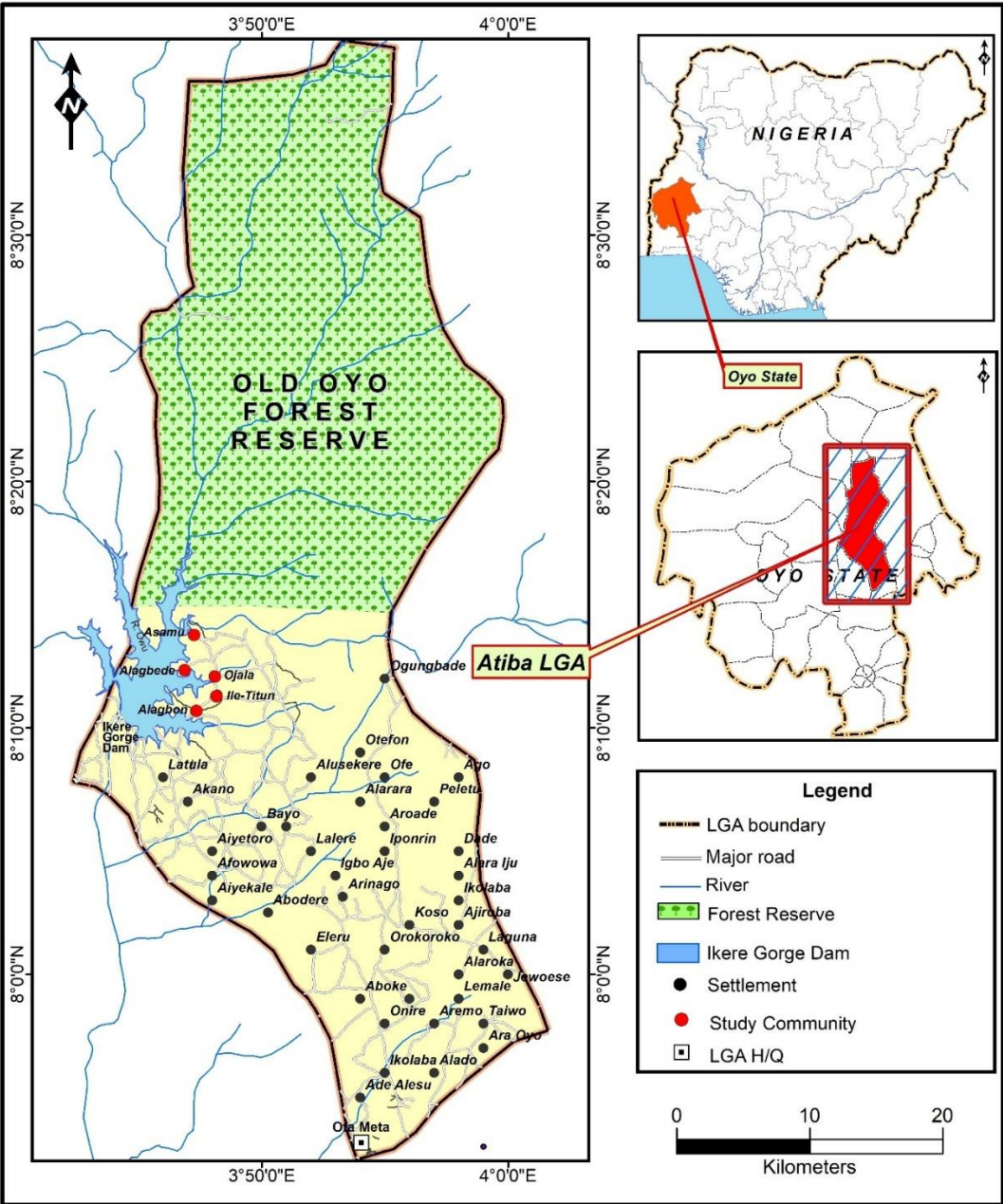


Figure 1. Map of Atiba LGA showing study communities. Created with ArcMap 10.8 version released by ESRI.

Table 1. Distance of study communities to Ikere Gorge Dam and Ibadan.

Study Community	Distance to Ikere Gorge Dam (km)	Distance to Ibadan
Alagbede	5.9km	92.0km
Asamu	8.4km	94.6km
Ojala	7.5km	91.4km
Ile titun	7.0km	89.9km
Alagbon	5.2km	88.8km

3.4. Urine Collection and Examination for *S. haematobium* Eggs

Urine sample collection was carried out at 10:00 and 14:00 hours of the day, when the body’s metabolic activity is relatively high. Samples were obtained from each individual in a well-labelled, sterilized, wide-mouthed, tight-capped plastic container. Samples were put on ice using ice packs

and transported to the laboratory immediately after collection for analysis. In the laboratory, urine specimens were processed by the standard filtration technique with microscopy (Figure 2), in which 10 mL of each sample was passed through a 20- μ m pore filter membrane to retain the *S. haematobium* eggs contained, which were thereafter examined and counted under a 40x objective lens of a light microscope to identify the ova, which are characterized by a terminal spine.

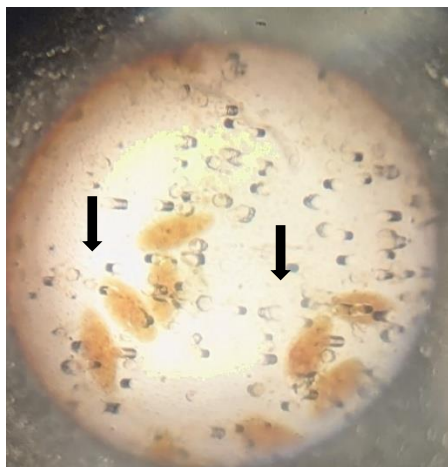


Figure 2. Photomicrograph of *Schistosoma haematobium* eggs in urine filter observed under light microscopy (filtration technique). Arrows indicate the characteristic eggs, identifiable by their oval shape and terminal spine.

A sterile syringe, a filtration tube with a 13 mm diameter O-ring rubber seal, and a polycarbonate membrane filter (PMF) with a diameter of 13 mm and a pore size of 20.0 microns, manufactured by Sterlitech Corporation Laboratories, United States of America, were used to capture *S. haematobium* eggs. The filter, which was held in a plastic 13 mm holder, was carefully removed and placed on a clean microscope slide and stained with a drop of 1% Lugol iodine solution. The stained slides were examined under the microscope, and the number of terminally spined *S. haematobium* eggs was counted and recorded. The mean egg intensity of infection was categorized as heavy (≥ 50 eggs/10 mL) and light (< 50 eggs/10 mL) in line with the current World Health Organization classification [41].

Physical observation: The colour and turbidity of each urine sample were carefully observed and recorded. The urine samples were categorized and documented as cloudy/dark (may indicate dehydration), brown/red (may indicate the presence of blood), clear/pale yellow (may indicate the presence of bilirubin), and green (may indicate the presence of pseudomonas infection) appearances [17].

3.5. Examination of Urine for Haematuria, Proteinuria and Leukocyturia

Haematuria, proteinuria and leukocyturia were examined by gently dipping a commercial reagent strip (Medi-test combi-10; MDSS GmbH Schiffgraben, Hannover, Germany) into the urine sample contained in sterile plastic bottle for 60s in accordance with the manufacturer's instructions. The colour change was then compared with the manufacturer's colour chart to estimate the amount of blood, protein and white blood cells in urine.

3.6. Snail Survey

All the water contact sites were searched for freshwater snails using long-hand scoops and hand-picking for 15 minutes at each water contact site. Snail sampling was conducted between September and December 2024. Snails were collected at various water contact sites in the five communities using standard scooping methods. The timing of collection may not have coincided with peak snail activity, and snail abundance can vary seasonally. Snails collected were transferred into clean, well-aerated plastic containers pre-labelled and transported to the Parasitology Laboratory of the Department of Zoology, University of Ibadan, Ibadan, for sorting into species types for identification. Snails were

identified using the morphological identification keys for West African freshwater snails by Brown and Kristensen [42]. Snails were identified according to shell morphology and structure using the standard identification key, such as shell shape (elongated, globose, or turreted), coiling pattern (sinistral or dextral), apex form (pointed or truncated), surface ornamentation (smooth, ridged, or tuberculate), aperture size and outline, and the presence or absence of an operculum.

3.7. Examination of Snails for Patent Infection

Pulmonate snails (*Bulinus truncatus*) collected from water-contact sites were examined for patent infections, and snails actively shedding cercariae [43,44] by placing each snail in a shedding vial containing 4–5 mL of dechlorinated tap water and exposing them to sunlight for approximately one hour. The contents of each vial were then examined under a microscope for the presence of cercariae. Snails releasing furcocercous cercariae were recorded as infected, and the cercariae were identified morphologically following the guide by Frandsen and Christensen [45]

3.8. Data Analysis

Data analysis was performed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) for Windows software package version 27.0 (SPSS Inc., Chicago, IL, USA). The raw data were first organized in Excel. Basic calculations, such as prevalence (%) and 95% confidence intervals (CI), were performed in Excel to assess the range of infection rates within each group, including gender and age groups. For a more detailed statistical analysis, SPSS version 27.0 was utilized. Descriptive statistics, including frequencies (n) and proportions (%), were calculated. SPSS was also used to compute the arithmetic mean ($X \pm SD$) for the number of eggs per 10 mL of urine. Chi-square (χ^2) tests were conducted to assess associations between prevalence and demographic characteristics, and to determine whether there were significant differences across groups such as gender, age, urinary abnormalities and community. The intensity of infection was categorized based on WHO recommendations: heavy intensity (≥ 50 eggs/10 mL) and light intensity (< 50 eggs/10 mL). The level of significance was set at $p < 0.05$. To assess the association between infection intensity (egg counts per 10 mL of urine) and the presence of urinary abnormalities (haematuria, proteinuria, and leukocyturia), the Wilcoxon rank-sum test (also known as the Mann–Whitney U test) was employed. This non-parametric test was used due to the non-normal distribution of egg count data.

4. Results

4.1. Characteristics of the Study Population

A total of 247 volunteer participants were recruited into the study, but only 239 submitted their urine samples for examination, and 69 of them were from the Alagbede community, while 63 were from the Asamu community, 13 were from the Ojala community, 47 were from the Ile Titun community, and 47 were from the Alagbon community. The sex ratio (M/F) of participants was 1.7, with 149 males (62.3%) and 90 females (37.7%). The ages of participants ranged from 5 to 90 years. The 5–9-year age group was the most represented, comprising 69 individuals (23 males and 46 females), and accounted for 44% of the total (Table 2).

Table 2. General characteristics of communities and participants in the UGS survey in the Atiba LGA, Oyo State.

Characteristics	Number Examined (Total= 239)	Percentage (%) 95% CL	P-value
Communities			
Alagbede	69	28.9 [26.5 - 43.3]	<0.001
Asamu	63	26.4 [16.2 -29.4]	

Ojala	13	5.4 [0.7-5.9]	
Ile Titun	47	19.7 [10.3 - 22.8]	
Alagbon	47	19.7 [16.2 - 30.1]	
Sex			
Male	149	62.3 [52.9 -72.1]	<0.001
Female	90	37.7 [27.9 - 47.1]	
Age group (years)			
Total	239	100 [100.0 – 100.0]	
5-9	69	28.9 [27.2 - 44.9]	<0.001
10-17	47	19.7 [18.4 - 36.0]	
18-27	25	10.5 [5.9 - 16.2]	
28-37	30	12.6 [2.2 - 11.0]	
38-50	26	10.9 [2.2 - 11.0]	
51-90	42	17.6 [7.4 - 19.1]	
Urine Colour			
Yellow	133	55.6 [36.8 - 55.9]	<0.001
Red	35	14.6 [17.6 - 30.9]	
Brown	37	15.5 [12.5 - 24.3]	
Clear	14	5.9 [2.9 - 10.3]	
Cloudy	20	8.4 [2.2 - 10.3]	

4.2. Overall Prevalence of UGS

A total of 239 individuals were examined for *S. haematobium* infection. Of these, 136 resulted in an overall prevalence of 56.9%. The prevalence of infection varied across the five communities (Table 3). The highest prevalence was recorded in Alagbede (69.6%), where 48/69 individuals tested positive. This was followed by Alagbon (68.1%), Asamu (47.6%), Ile Titun (46.8%), and Ojala (30.8%). The difference in prevalence across the five communities was statistically significant ($p < 0.05$), as presented in Table 3

Table 3. Prevalence and mean intensity of urogenital schistosomiasis by age group in Atiba LGA, Oyo State.

Variable		Number examined	Number infected	Prevalence (%)	P-value	Mean Intensity ± SD Eggs/10mL of Urine
Infection Status	Urine samples	239	136	56.9	<0.001	
Communities	Alagbede	69	48	69.6	0.005	42.35±28.42
	Asamu	63	30	47.6		41.03±25.89
	Ojala	13	4	30.8		1.25±0.50
	Ile titun	47	22	46.8		86.05±210.65
	Alagbon	47	32	68.1		110.84±158.76
Sex	Male	149	83	55.7	0.630	76.95±148.55
	Female	90	53	58.9		43.81±34.16
Age group (years)	5-9	69	49	71.0	<0.001	86.94±128.41
	10-17	47	37	78.7		87.62±163.29
	18-27	25	15	60.0		22.6±25.27
	28-37	30	9	30.0		29.89±28.02
	38-50	26	8	30.8		29.50±24.25
	51 and above	42	18	42.9		29.50±21.98
Urine Colour	Yellow	133	64	48.1	<0.001	37.94±49.24
	Red	35	32	91.4		127.63±206.47
	Brown	37	24	64.9		67.83±100.07

Intensity Status	Clear	14	8	57.1	26.75±26.22
	Cloudy	20	8	40.0	44.38±35.15
	Light	239	67	28.0	<0.001
	Heavy		69	28.9	

4.3. Association Between Urine Characteristics and Infection Status

Urine colour was associated with infection status. Participants with red coloured urine (macrohaematuria) had the highest prevalence of infection (91.4%, 32/35), followed by those with brown (64.9%), clear (57.1%), yellow (48.1%), and cloudy urine (40.0%) ($p<0.001$), as presented in Table 3.

4.4. Intensity of Infection (Egg Count per 10 mL of Urine) and Prevalence of Schistosomiasis by Age

The intensity of infection was classified per WHO guidelines as light (<50 eggs/10 mL) or heavy (≥ 50 eggs/10 mL). Among the 239 participants, 136 (56.9%) tested positive, of which 67 (49.3%) had light infections and 69 (50.7%) had heavy infections, with an overall mean intensity of 64.04 eggs/10 mL of urine ($SD \pm 118.81$). Males had a higher mean intensity (76.95 eggs/10 mL; $SD \pm 148.55$) than the females (43.81 eggs/10 mL; $SD \pm 34.16$). The highest mean intensity of 110.84 egg/10 mL of urine was recorded in Alagbon community. Thus, the mean intensity of infection varied by community, ranging from ~2 eggs/10 mL in Ojala up to ~111 eggs/10 mL in Alagbon (Table 3). Additionally, the mean intensity of infection among the various age groups gradually decreased with increasing age, and the highest mean intensity of infection of 87.62 egg/10 mL of urine was among the age group 10-17 years, while the least was among the age group 18-27 years (Table 4). The differences were statistically significant ($p < 0.05$). Overall, females exhibited a higher prevalence across the communities (Table 7). By age group, the highest prevalence of infection (78.7%) was recorded among participants aged 10–17 years. In contrast, lower prevalence rates of *S. haematobium* infection were observed among those aged 28–37 years (30.0%), 38–50 years (30.8%), and 51–90 years (42.9%) ($p < 0.001$). (Table 4).

4.5. Prevalence of Urinary Abnormalities of Infected Individuals

Among the 239 individuals examined, the prevalence of haematuria, proteinuria, and leukocyturia was 42.3%, 41.8%, and 22.6%, respectively. Each of these urinary abnormalities showed a statistically significant association with *S. haematobium* infection ($p < 0.05$). There was a significant difference in the prevalence of haematuria among males (59.1%) and females (61.7%) ($\chi^2 = 0.0521$, $p = 0.8195$). Proteinuria showed a notable disparity, affecting 58.4% of females compared to only 20.1% of males ($\chi^2 = 0.1469$, $p = 0.7015$). Similarly, leukocyturia was more prevalent in females (64.5%) than in males (30.0%) ($\chi^2 = 1.7680$, $p = 0.1836$). While gender-based trends in urinary abnormalities were apparent, particularly for proteinuria and leukocyturia, the chi-square test did not indicate statistically significant associations (Table 5).

Table 4. Age-based prevalence and clinical characteristics of UGS across different communities in Atiba Local Government Area, Oyo State.

Community Surveyed	Age group (years)	No. Examined	No. Infected	Prevalence () [95 CL]	X ² (P-value)	Arithmetic Mean (X±SD) Eggs/10mL of Urine [95 CL]	Haematuria [95 CL]	Proteinuria [95 CL]	Leukocyturia [95 CL]	Light Intensity (<50 Eggs/10mL of Urine) % [95% CL]	Heavy intensity (≥50 Eggs/10mL of Urine) % [95% CL]
Alagbede	5-9	16	13	81.3 [59.0 - 100.0]	X ² =4.641 (p=0.461)	58.75 ± 2.99 [55.82 - 61.68]	93.8 [38.5 – 71.5]	87.5 [45.7 – 79.3]	37.5 [3.1 - 31.8]	93.8% [38.5 - 71.5]	87.5% [45.7 - 79.3]
	10-17	12	10	83.3 [61.7 - 100.0]		66.75 ± 2.75 [64.05 - 69.45]	75 [36.6 - 73.7]	58.3 [29.5 - 67.1]	41.7 [7.0 – 34.4]	75.0% [36.6 - 73.7]	58.3% [29.5 - 67.1]
	18-27	13	8	61.5 [32.0 - 91.0]		48.75 ± 2.99 [45.82 - 51.68]	61.5 [36.6 - 73.7]	53.8 [29.5 - 67.1]	7.7 [7.0 – 34.4]	61.5% [36.6 - 73.7]	53.8% [29.5 - 67.1]
	28-37	8	6	75.0 [45.0 - 105.0]		55.25 ± 1.71 [53.58 - 56.92]	12.5 [36.6 - 73.7]	37.5 [29.5 - 67.1]	0 [7.0 - 34.4]	12.5% [36.6 - 73.7]	37.5% [29.5 - 67.1]
	38-50	7	4	57.1 [21.0 - 93.0]		47.5 ± 2.08 [45.46 - 49.54]	28.6 [36.6 - 73.7]	28.6 [29.5 - 67.1]	0 [7.0 – 34.4]	28.6% [36.6 - 73.7]	28.6% [29.5 - 67.1]
	51 and above	13	7	53.8 [23.5 - 84.1]		48.0 ± 1.83 [46.21 - 49.79]	23.1 [36.6 - 73.7]	46.2 [45.7 - 79.3]	7.7 [7.0 - 34.4]	23.1% [36.6 - 73.7]	46.2% [45.7 - 79.3]
Asamu	5-9	17	11	64.7 [42.7 - 86.7]	X ² =19.235 (p=0.002)	42.5 ± 2.08 [40.46 - 44.54]	88.2 [31.8 - 61-6]	88.2 [31.8 - 61.6]	47.1 [10.1 - 38.7]	88.2% [31.8 - 61.6]	88.2% [31.8 - 61.6]
	10-17	12	10	83.3 [61.7 - 100.0]		49.25 ± 2.22 [47.08 - 51.42]	91.7 [36.6 - 73.7]	91.7 [29.5 - 67.1]	58.3 [7.0 – 34.4]	91.7% [36.6 - 73.7]	91.7% [29.5 - 67.1]
	18-27	3	2	66.7 [22.0 - 111.4]		60.25 ± 1.71 [58.58 - 61.92]	66.7 [36.6 - 73.7]	33.3 [29.5 - 67.1]	66.7 [7.0 – 34.4]	66.7% [36.6 - 73.7]	33.3% [29.5 - 67.1]
	28-37	13	1	7.7 [0.0 - 22.6]		38.5 ± 1.29 [37.23 - 39.77]	15.4 [36.6 - 73.7]	7.7 [29.5 - 67.1]	0 [7.0 – 34.4]	15.4% [36.6 - 73.7]	7.7% [29.5 - 67.1]
	38-50	9	2	22.2 [0.0 - 61.5]		48.5 ± 1.29 [47.23 - 49.77]	11.1 [36.6 - 73.7]	22.2 [29.5 - 67.1]	11.1 [7.0 – 34.4]	11.1% [36.6 - 73.7]	22.2% [29.5 - 67.1]
Ojala	51 and above	9	4	44.4 [14.3 - 74.5]	X ² =1.499 (p=0.683)	45.5 ± 1.29 [44.23 - 46.77]	22.2 [36.6 - 73.7]	44.4 [29.5 - 67.1]	11.1 [7.0 – 34.4]	22.2% [36.6 - 73.7]	44.4% [29.5 - 67.1]
	18-27	4	1	25.0 [0.0 - 55.0]		70.25 ± 1.71 [68.58 - 71.92]	25 [3.6 - 36.4]	50 [14.7 - 65.3]	25 [0.4 - 9.6]	100.0% [39.8 - 100.0]	0.0% [0.0 - 60.2]
	28-37	2	1	50.0		65.0 ± 1.41	50	100	0	50.0%	100.0%

				[0.0 - 100.0]			[63.12 - 66.88]	[3.6 - 36.4]	[14.7 - 65.3]	[0.4 - 19.6]	[3.6 - 36.4]	[14.7 - 65.3]
	38-50	2	0	0.0			0.0 ± 0.0	0	50	50	0.0%	50.0%
				[0.0 - 0.0]			[0.0 - 0.0]	[0.0 - 0.0]	[4.2 - 29.2]	[4.2 - 29.2]	[0.0 - 0.0]	[4.2 - 29.2]
	51 and above	5	2	40.0			55.0 ± 1.41	40	50	50	40.0%	50.0%
				[0.0 - 80.0]			[53.12 - 56.88]	[0.0 - 0.0]	[4.2 - 29.2]	[4.2 - 129.2]	[0.0 - 0.0]	[4.2 - 29.2]
Ile Titun	5-9	14	6	42.9			48.5 ± 1.29	57.1	78.6	7.1	57.1%	78.6%
				[15.9 - 69.9]			[47.23 - 49.77]	[31.1 - 73.7]	[45.7 - 79.3]	[3.1 - 31.8]	[31.1 - 73.7]	[45.7 - 79.3]
	10-17	14	8	57.1			51.5 ± 1.29	64.3	85.7	14.3	64.3%	85.7%
				[31.9 - 82.3]			[50.23 - 52.77]	[22.6 - 62.0]	[49.7 - 94.7]	[3.8 - 34.6]	[22.6 - 62.0]	[49.7 - 94.7]
	18-27	5	4	80.0			60.25 ± 1.71	80.0	20.0	20.0	80.0%	20.0%
				[34.0 - 100.0]	X ² =4.819		[58.58 - 61.92]	[22.6 - 62.0]	[49.7 - 94.7]	[3.8 - 34.6]	[22.6 - 62.0]	[49.7 - 94.7]
	28-37	4	1	25.0	(p=0.438)		40.5 ± 1.29	50.0	25.0	25.0	50.0%	25.0%
				[0.0 - 58.0]			[39.23 - 41.77]	[22.6 - 62.0]	[49.7 - 94.7]	[3.8 - 34.6]	[22.6 - 62.0]	[49.7 - 94.7]
	38-50	3	1	33.3			50.5 ± 1.29	33.3	66.7	0	33.3%	66.7%
				[0.0 - 80.0]			[49.23 - 51.77]	[22.6 - 62.0]	[49.7 - 94.7]	[3.8 - 34.6]	[22.6 - 62.0]	[49.7 - 94.7]
	51 and above	7	2	28.6			45.5 ± 1.29	57.1	28.6	57.1	57.1%	57.1%
				[0.0 - 57.0]			[44.23 - 46.77]	[49.7 - 94.7]	[22.6 - 62.0]	[3.8 - 34.6]	[49.7 - 94.7]	[22.6 - 62.0]
Alagbon	5-9	22	19	86.4			60.25 ± 1.71	95.5	100	22.7	95.5%	100%
				[74.6 - 98.2]			[58.58 - 61.92]	[68.6 - 95.0]	[83.2 - 98.6]	[3.2 - 33.2]	[68.6 - 95.0]	[83.2 - 98.6]
	10-17	9	9	100.0			70.5 ± 1.29	100	100	33.3	100%	100%
				[100.0 - 100.0]			[69.23 - 71.77]	[72.4 - 99.1]	[59.7 - 97.5]	4.3 - 52.9]	[72.4 - 99.1]	[59.7 - 97.5]
	28-37	3	0	0.0			0.0 ± 0.0	33.3	66.7	0	33.3%	66.7%
				[0.0 - 0.0]	X ² =22.766		[0.0 - 0.0]	[0.0 - 0.0]	[72.4 - 99.1]	[0.0 - 0.0]	[0.0 - 0.0]	[72.4 - 99.1]
	38-50	5	1	20.0	(p<0.001)		48.5 ± 1.29	60.0	80.0	20.0	60.0%	80.0%
				[0.0 - 50.0]			[47.23 - 49.77]	[68.6 - 95.0]	[83.2 - 98.6]	[3.2 - 33.2]	[68.6 - 95.0]	[83.2 - 98.6]
	51 and above	8	3	37.5			45.5 ± 1.29	62.5	50.0	12.5	62.5%	50.0%
				[11.8 - 63.2]			[44.23 - 46.77]	[72.4 - 99.1]	[59.7 - 97.5]	[4.3 - 52.9]	[72.4 - 99.1]	[59.7 - 97.5]

Table 5. Association between the prevalence of urinary abnormalities across gender (Chi-square test).

Urinary abnormality	Number examined	Number infected	Prevalence (%)	Test of	Gender		χ^2 value	df	Test of	association
					Prevalence	Prevalence				
Haematuria	239	101	42.26	<0.001	59.06	61.67	0.0521	1	0.8195	
Proteinuria	239	100	41.84	<0.001	20.07	58.44	0.1469	1	0.7015	
Leukocyturia	239	54	22.59	<0.001	30.02	64.46	1.7680	1	0.1836	

Among the 239 individuals examined, the prevalence of haematuria, proteinuria, and leukocyturia was 42.3%, 41.8%, and 22.6%, respectively. Each of these urinary abnormalities showed a statistically significant association with *S. haematobium* infection ($p < 0.05$). There was a significant difference in the prevalence of haematuria among males (59.1%) and females (61.7%). Proteinuria showed a notable disparity, affecting 58.4% of females compared to only 20.1% of males. Similarly, leukocyturia was more prevalent in females (64.5%) than in males (30.0%). While gender-based trends in urinary abnormalities were apparent, particularly for proteinuria and leukocyturia, the chi-square test did not indicate statistically significant associations (Table 5).

Haematuria, proteinuria, and leukocyturia varied across the five communities and by gender. Alagbon recorded the highest haematuria (males 81.8%, females 85.7%) and proteinuria (males 90.9%, females 78.6%), while leukocyturia was notably high among Ojala females (66.7%) compared to males (10%). Generally, males and females had similar prevalence of haematuria and proteinuria, though some disparities existed in Alagbede and Ile Titun. Age-wise, participants aged 5–9 and 10–17 years consistently showed the highest burden of urinary abnormalities, aligning with peak *S. haematobium* prevalence. Those with haematuria or proteinuria had higher egg counts (median 53–53.5 eggs/10 mL), indicating a clear association between urinary markers and infection intensity (Table 6).

Table 6. Association between egg count (eggs/10 mL of urine) and urinary abnormalities.

Abnormalit	Median eggs/10	Mean eggs/10	n	Wilcoxon	p-
y	mL of urine	mL of urine		W	value
Haematuria	53	76.2	101	1105	0.001
Proteinuria	53.5	77.7	100	1044	0.0002

Abnormality	Median eggs/10 mL of urine	Mean eggs/10 mL of urine	n	Wilcoxon W	p-value
Leukocyturia	58	59.8	54	1533	0.029
a					

4.6. Prevalence of Schistosomiasis by Gender and Community

Table 7 shows that across the five communities, gender-related differences in *S. haematobium* infection were observed. In Alagbede, females had a slightly higher prevalence (72.4%) than males (67.5%) ($p = 0.19$), with comparable mean intensities (39.59 eggs/10 mL in males and 45.90 eggs/10 mL). Heavy infections were more frequent among females (66.7%; 95% CI=43.0-85.4) than males (44.4%; 95% CI=25.5-64.7). In Asamu, females had a higher prevalence (61.1%) than males (42.2%) ($p = 0.09$). However, the mean intensity was slightly lower in females (40.64 eggs/10 mL) than in males (41.26 eggs/10 mL).

Table 7. Gender-Based prevalence and clinical characteristics of UGS across the studied communities in Atiba Local Government Area, Oyo State.

Community Surveyed	Sex	No. Examined	No. Infected	Prevalence (%) [95% CL]	X ² (P-value)	Arithmetic Mean (X±SD) Eggs/10mL of Urine [95% CL]	Haematuria [95% CL]	Proteinuria [95% CL]	Leukocyturia [95% CL]	Light Intensity (<50 Eggs/10 mL) % [95% CL]	Heavy Intensity (≥50 Eggs/10 mL) % [95% CL]
Alagbede	Male	40	27	67.5 [47.7 - 87.3]	X ² =0.189 (p=0.191)	39.59 ± 28.36 [28.89 - 50.29]	55 [0.385 - 0.715]	62.5 [0.457 - 0.793]	17.5 [0.031 - 0.318]	55.6 [35.3–74.5]	44.4 [25.5–64.7]
	Female	29	21	72.4 [50.9 - 93.9]	-	45.90 ± 28.80 [33.59 - 58.22]	55 [0.366 - 0.737]	48.3 [0.295 - 0.671]	20.7 [0.070 - 0.344]	33.3 [14.6–57.0]	66.7 [43.0–85.4]
Asamu	Male	45	19	42.2 [26.7 - 57.7]	X ² =1.810 (p=0.09)	41.26 ± 25.72 [29.70 - 52.83]	46.7 [0.318 - 0.616]	46.7 [0.318 - 0.616]	24.4 [0.101 - 0.387]	36.8 [16.3–61.6]	63.2 [38.4–83.7]
	Female	18	11	61.1 [32.5 - 89.7]	-	40.64 ± 27.45 [24.41 - 56.86]	66.7 [0.406 - 0.928]	72.2 [0.497 - 0.947]	44.4 [0.203 - 0.685]	36.4 [10.9–69.2]	63.6 [30.8–89.1]
Ojala	Male	10	4	40.0 [7.0 - 73.0]	X ² =1.600 (p=0.294)	1.25 ± 0.50 [0.76 - 1.74]	20.0 [0.036 - 0.364]	40.0 [0.147 - 0.653]	10.0 [0.004 - 0.196]	100.0 [39.8–100.0]	0.0 [0.0–60.2]
	Female	3	0	0.0 [0.0 - 0.0]	-	-	0.0 [0.000 - 0.000]	66.7 [0.042 - 1.292]	66.7 [0.042 - 1.292]	0.0 [0.0–0.0]	0.0 [0.0–0.0]
Ile Titun	Male	21	10	47.6 [21.2 - 74.0]	X ² =0.010 (p=0.23)	153.00 ± 303.59 [35.17 - 341.17]	76.2 [0.311 - 0.737]	52.4 [0.189 - 0.876]	19.0 [0.043 - 0.529]	70.0 [34.8–93.3]	30.0 [6.7–65.2]
	Female	26	12	46.2 [19.3 - 73.1]	-	30.25 ± 42.82 [6.02 - 54.48]	42.3 [0.226 - 0.620]	69.2 [0.497 - 0.947]	19.2 [0.038 - 0.346]	83.3 [51.6–97.9]	16.7 [2.1–48.4]
Alagbon	Male	33	23	69.7 [54.5 - 84.8]	X ² =0.231 (p=0.096)	130.39 ± 183.24 [55.50 - 205.28]	81.8 [0.686 - 0.950]	90.9 [0.832 - 0.986]	18.2 [0.032 - 0.332]	43.5 [23.2–65.5]	56.5 [34.5–76.8]
	Female	14	9	64.3 [39.5 - 89.0]	-	60.89 ± 37.68 [36.27 - 85.51]	85.7 [0.724 - 0.991]	78.6 [0.597 - 0.975]	28.6 [0.043 - 0.529]	33.3 [7.5–70.1]	66.7 [29.9–92.5]

Heavy infections were recorded in 63.6% of females (95% CI: 30.8–89.1) and 63.2% of males (95% CI: 38.4–83.7). In Ojala, only males were infected (40%, $p = 0.294$), all with a mean intensity of 1.25 eggs/10 mL and a light intensity of 100% (95% CI = 39.8–100.0). Ile Titun had a slightly higher prevalence in male 47.6% and 46.2% in female ($p=0.23$), the males had a higher mean egg intensity (153.0 eggs/10 mL) than the females (30.25 eggs/10 mL) and light infections were recorded in 83.3% of females (95% CI: 51.6–97.9) and 70% of males (95% CI: 34.8–93.3). In Alagbon, males had a slightly higher prevalence (69.7%) than females (64.3%) ($p=0.096$) and marginally higher intensity (130.49 eggs/10 mL) than females (60.89 eggs/10 mL), but females had heavier infections (66.7%; 95% CI=29.9–92.5) than males (56.5%; 95% CI=34.5– 76.8).

4.7. Overall Snail Diversity and Abundance

The fauna of freshwater snails collected in Atiba LGA is composed of 7 species (Table 8) belonging to the type of snail Pulmonate (*Aplexa waterloti*, and *Bulinus truncatus*) and Prosobranch (*Bellamya unicolor*, *Gabiella spirilosa*, *Melanoides tuberculata*, *Hydrobia sp.*, and *Pila ovata*). The overall count of the freshwater snails during the study period gives 407 freshwater snails, with *Melanoides tuberculata* (173/407) and *Hydrobia sp.* (99/407) more abundant, while *Bulinus truncatus* (2/407), *Bellamya unicolor* (2/407), and *Pila ovata* (4/407) are less represented. *B. truncatus* (2/407) dominates among freshwater snails of medical and veterinary interest. A higher diversity of freshwater snail species was found in Asamu (184/407) compared to the other communities; however, the focus in this study was on the pulmonate snails, and *B. truncatus* was the only snail intermediate host encountered in this study. The two *B. truncatus* collected were observed to shed furcocercous cercariae of *Schistosoma* spp. cercariae and tested positive (Table 8).

Table 8. Abundance and distribution of freshwater snails across water bodies in Atiba LGA.

Snail Species	Type of snail	Asamu community		Alagbede community		Ojala community		Alagbon community		Total (%)
		No. collected (%)	No. with patent Furcocercous schistosome-like cercariae (%)	No. collected (%)	No. with patent Schistosoma infection (%)	No. collected (%)	No. with patent Schistosoma infection (%)	No. collected (%)	No. with patent Schistosoma infection (%)	
<i>Aplexa waterloti</i>	Pulmonate	9	0(0.0)	28	0(0.0)	18	0(0.0)	0	0(0.0)	55(13.5)
<i>Bulinus truncatus</i>	Pulmonate	2	2(100)	0	0(0.0)	0	0(0.0)	0	0(0.0)	2(0.49)
<i>Belamya unicolor</i>	Prosobranch	1	0(0.0)	0	0(0.0)	1	0(0.0)	0	0(0.0)	2(0.49)
<i>Gabiella spirilosa</i>	Prosobranch	0	0(0.0)	18	0(0.0)	0	0(0.0)	54	0(0.0)	72(17.69)
<i>Melanoides tuberculata</i>	Prosobranch	89	0(0.0)	48	0(0.0)	25	0(0.0)	11	0(0.0)	173(42.51)
<i>Hydrobia sp.</i>	Prosobranch	83	0(0.0)	12	0(0.0)	0	0(0.0)	4	0(0.0)	99(24.32)
<i>Pila ovata</i>	Prosobranch	0	0(0.0)	1	0(0.0)	1	0(0.0)	2	0(0.0)	4(0.98)
Total		184	2(1.09)	107	0(0.0)	45	0(0.0)	71	0(0.0)	407

5. Discussion

This study, revealing an overall prevalence of 56.9% for UGS among residents of five underserved communities in Atiba Local Government Area, Oyo State, could probably be because these communities are located near the Ikere George Dam, a major water body, and had previously lacked specific epidemiological data on UGS. Our findings indicate a significant disease burden, with marked variation in prevalence across the communities surveyed. The highest prevalence was recorded in Alagbede (69.6%), followed by Alagbon (68.1%), which were identified as hyperendemic for schistosomiasis. These findings are consistent with reports from other endemic communities in Nigeria that share similar environmental and socio-behavioural characteristics with our study site. For instance, a prevalence of 45.6% was reported in Ajagba (Oyo East LGA) in Oyo State [40], 77.3% in Ndokwa-East of Delta State [12], 48.4% in the riverine areas of Ondo State [46], 69% in Zobiya communities of Jigawa State [5], and 68% in Ebonyi LGA of Ebonyi State [47].

The Ojala community had a comparatively lower prevalence (30.8%) of infection in this study. While this may partly be attributed to the smaller sample size ($n = 13$), it is important to note that the sample still met the minimum requirement for statistical analysis. Nonetheless, the prevalence observed remains significantly higher than both the national average of 13% reported in 2017 [48] and the 10.4% prevalence reported in the 2021 multi-state survey [49]. It is also comparable to the 32% prevalence recorded by Onyekwere et al. (2022) among school children in Alie Ilie, Osun State, which was due to their better access to clean water and stronger control efforts in that region [51], 32.5% in Tanzania [52] and 34.2% in Ethiopia [53].

Although risk factors were not directly assessed in the present study, the variation in prevalence among the communities is likely influenced by well-established drivers of UGS transmission, such as proximity to infested water bodies, frequency of water contact, and the presence of intermediate snail hosts. Routine activities like bathing, laundry, and fishing, especially in communities dependent on open freshwater sources, are known to increase exposure risk and may help explain the high prevalence observed in Alagbede and Alagbon communities.

Gender-based analysis revealed a slightly higher prevalence among females than males, although the differences were not statistically significant ($p > 0.05$). These findings contrast with earlier studies [14,32,35,54,55], which reported a higher prevalence among males due to their occupational water contact activities. Conversely, other studies have reported a higher prevalence among females [27,56–58], which may be associated with limited access to healthcare, lack of awareness about disease transmission, insufficient clean water, and poverty. In rural southwestern Nigeria, domestic tasks such as laundry, bathing, and fetching water may expose females to equal or greater risk, emphasizing the need for gender-sensitive interventions [58]. Women in high-burden schistosomiasis environments may also face occupational risks through domestic and livelihood-related activities, including washing, fetching water, and even fishing practices, that are not traditionally associated with women. Thus, the observed gender-related differences in schistosomiasis prevalence and intensity likely result from a complex interplay between behavioural exposures and biological factors [34,59].

The highest prevalence of *S. haematobium* infection in this study was observed among individuals aged 10–17 years (78.7%), followed by those aged 5–9 years (71.0%). This pattern aligns with existing studies that identify school-aged children as the most affected demographic, largely due to frequent water contact activities such as swimming, bathing, and household chores that increase exposure to infested water. Awosolu et al. [60] reported a prevalence of 65.9% among children aged 10–14 years in southwestern Nigeria, emphasizing the high burden of schistosomiasis in this age group. Similar findings have been documented in other Nigerian studies [12,61,62]. This heightened vulnerability is largely attributed to behavioural patterns, as children in this age group are typically more active and frequently engage in water-related activities, including swimming and fetching water from rivers and streams, which are often contaminated [63,64].

The trend of high overall prevalence of schistosomiasis among school-aged children is not unique to Nigeria but has been consistently observed in other endemic countries, including Ethiopia, Cameroon, South Africa, Gabon, and Madagascar [35,65–69]. The decline in prevalence observed among older age groups may reflect the development of partial immunity from repeated exposure over time or a reduction in high-risk behaviours as individuals grow older [70]. These consistent trends across multiple regions and studies emphasize the need for targeted interventions focused on school-aged children, who remain the most at-risk group for UGS in most endemic settings.

Given that the intensity of infections was classified as heavy and light based on egg counts, the presence of heavy infections exclusively within the 10–17-year age group in this study is concerning. The highest mean intensity was observed among children aged 10–17 years, and similar patterns have been reported in other endemic African countries [47,71,72]. Furthermore, the mean intensity of infection demonstrated an inverse relationship with age, decreasing progressively as age increased. This pattern is likely attributable to lower levels of acquired immunity in younger individuals, in contrast to older age groups, who may have developed partial immunity due to prolonged or repeated exposure to the parasite [70].

A substantial proportion (28.9%) of *S. haematobium* infections observed in this study were classified as heavy (≥ 50 eggs/10 mL of urine), suggesting that many individuals in the study area not only harboured the parasite but also carried a high worm burden, placing them at elevated risk for chronic morbidity. This pattern has been associated with the frequency and duration of contact with contaminated water sources, as well as the lack of timely treatment [73]. Individuals with frequent exposure to infested water bodies are at greater risk of acquiring intense infections, which is concerning due to the association between infection intensity and severe pathological outcomes, such as haematuria, bladder wall pathology, hydronephrosis, and increased risk of bladder cancer [74,75].

The highest mean intensity of infection was recorded in males (76.95 ± 148.55 eggs/10 mL), indicating a gender-specific pattern in which males bore a higher egg burden than females. This observation aligns with previous studies reporting greater mean egg counts among male participants [61,76,77]. The higher mean egg count among males in this study is likely due to gender-specific water-contact activities, as males tend to engage more in fishing, swimming, and playing in water naked, exposing them to higher infection intensity compared with females.

The detection of blood in urine using reagent strips has been recognized as a reliable alternative for diagnosing *S. haematobium* infection [78,79]. The observed statistical associations between *S. haematobium* infection and haematuria, proteinuria, and leukocyturia suggest that these urinary abnormalities may serve as important diagnostic indicators. Similar findings have been reported in Kenya [80], Senegal [81], and Ghana [82]. Notably, red-coloured urine, a clinical sign of haematuria, had the highest prevalence in this study, occurring in 91.4% of cases [83], emphasizing the heightened vulnerability of school-aged children and adolescents to schistosomiasis-related morbidity across the study area.

The high prevalence of haematuria observed was consistent with the presence of *S. haematobium* eggs, reinforcing its diagnostic potential, a relationship also documented in previous studies [84–86]. In addition, notable prevalences of proteinuria (41.8%) and leukocyturia (22.6%) were recorded in the endemic communities. Macrohaematuria (visible red urine) and microhaematuria were present in 91.4% and 42.3% of participants, respectively. While not all cases of haematuria are directly caused by *S. haematobium*, the presence of blood in urine remains an early and valuable indicator of infection [83]. Haematuria results from granulomatous inflammation caused by the deposition of *S. haematobium* eggs in the bladder wall and urogenital tissues [87,88]. Despite the possibility of false positives due to persistent microhaematuria, chronic bladder lesions, or physiological factors such as menstruation or pregnancy in women, haematuria continues to be a reliable and practical diagnostic marker, particularly in high-risk populations [89,90].

In this study, haematuria and proteinuria were more prevalent in females, whereas leukocyturia was higher among males. While a previous study [79] reported higher levels of microhaematuria, proteinuria, and leukocyturia in females, our findings partially align, confirming the higher

prevalence of haematuria and proteinuria in females but revealing greater leukocyturia in males. This discrepancy may be attributed to differences in study populations, infection intensity, or diagnostic methods. Our results are consistent with earlier studies in Nigeria [22,91–93], which documented a high prevalence of urinary abnormalities among infected children, as well as studies from other endemic countries [85,94–96]. These urinary abnormalities not only signify active *S. haematobium* infection but may also indicate potential complications such as chronic kidney disease, genital schistosomiasis, and bladder damage if left untreated [97,98].

It is important to note that the urine filtration technique, although widely applied, has limitations in detecting light infections (<50 eggs per 10 mL of urine), with variable sensitivity reported in previous studies [84,89]. Furthermore, with growing evidence of reduced efficacy and possible resistance to praziquantel in some endemic areas, reliance on a single diagnostic or treatment approach may underestimate the true burden of schistosomiasis and hinder effective control. Consequently, some infected individuals, both children and adults, may have tested negative using this method. This emphasizes the need to incorporate more sensitive diagnostic tools, such as molecular techniques, in future surveys to improve detection accuracy for *S. haematobium* [99].

In this study, heavy infection intensity was significantly associated with urinary tract morbidities, corroborating findings from earlier studies [100,101]. Heavy *S. haematobium* infections are recognized as indicators of severe urinary complications, as approximately 50% of the eggs are excreted in urine [102]. This implies that a substantial number of eggs remain lodged within the vasculature of the urogenital tract, contributing to chronic inflammation and the development of serious pathological conditions in the host [102,103].

Of the seven freshwater snail species collected, only one was of medical and veterinary importance, due to its role as an intermediate host for human and animal parasites. The water site at Asamu community harboured a greater diversity of snail species, including *Bulinus truncatus*, although in small numbers. Two of the *Bulinus truncatus* snails were observed to be shedding furcocercous cercariae, indicating patent infection and possible active transmission of schistosomiasis. In contrast, the water sites in the other communities contained fewer snail species, and none of the species known to transmit *S. haematobium* were found during the study. Interestingly, the Alagbede community, despite recording the highest prevalence of *S. haematobium* infection among humans, did not yield any snail hosts capable of transmitting the parasite. This discrepancy might be attributed to the timing of malacological sampling, which may not have coincided with peak snail activity. Such disconnects between snail host presence and human infection have also been reported in endemic settings and may reflect historical transmission patterns, seasonal snail population dynamics, or human movement across communities [104–106].

6. Conclusion

Urogenital schistosomiasis remains a serious endemic disease in the study area, with school-aged children, particularly those aged 10–17 years, bearing the highest burden due to behavioural exposure and immunological susceptibility. The strong association between UGS and urinary abnormalities (haematuria, proteinuria, and leukocyturia) emphasizes both their diagnostic value and the potential long-term health risks if left untreated.

The high prevalence of UGS observed in the study communities reflects not only ecological exposure but also broader systemic challenges, including limited access to safe water, poor infrastructure, weak healthcare systems, and insecurity, which sustain transmission. *Bulinus truncatus* was implicated in transmission in the Asamu community. Addressing this burden requires integrated interventions, including the provision of safe water, mass drug administration with praziquantel, health education, snail control, and continued research into re-infection, drug resistance, vaccines, and improved diagnostics. These strategies are essential for effective control and eventual elimination of schistosomiasis in endemic regions.

Future Research Directions

The present study provides valuable data on the prevalence, intensity, and clinical correlates of schistosomiasis in the surveyed communities; further work is needed to strengthen the evidence base. Longitudinal studies should be conducted to monitor seasonal transmission dynamics, treatment outcomes, and reinfection patterns over time. In addition, the integration of molecular techniques for snail identification, cercarial shedding analysis, and human-animal schistosoma hybridization would provide a more accurate understanding of the parasite, intermediate host species involved and their role in sustaining transmission. Future investigations would also explore environmental and socio-behavioural drivers of infection, as well as the potential impact of integrated control measures combining chemotherapy, snail control, and improved water, sanitation, and hygiene (WASH) interventions.

Limitations of the Study

Our study had several limitations. Firstly, the sample size was moderate, although it was determined using standard guidelines for estimating the minimum sample required for a community-based survey, and was therefore considered adequate [107]. Secondly, the urine filtration technique for microscopy was performed only once per participant; repeating the procedure would have improved the likelihood of detecting additional parasite eggs. Thirdly, although microscopy of urine samples using the urine filtration technique is considered the gold standard for diagnosing UGS, in this study, diagnosis relied solely on this method, alongside dipstick assays for urinary haematuria, proteinuria, and leukocyturia as recommended indicators [108]. More sensitive molecular methods, such as PCR-based detection of schistosome DNA in human urine or serum, were not considered [109]. Fourthly, infection prevalence in snails was assessed solely through cercarial shedding, which detects only patent infections. Including methods to detect both patent and prepatent infections would have provided a more sensitive and accurate estimate. Finally, molecular identification of *Bulinus* snails, *Schistosoma* cercariae, and parasites from the study sites might help confirm whether the freshwater bodies in these communities serve as transmission foci for human or animal schistosomiasis and provide evidence of possible hybridization events.

Institutional Review Board Statement: The study protocol was reviewed and approved by the Ethical Committee of the Oyo State Ministry of Health (NHREC/OYOSHRIEC/10/11/22) and the University of Ibadan/University College Hospital Ethical Review Committee (UI/EC/24/01022). Permission was obtained from the Chairman of the State Primary Health Care Board, the NTD officers, and the village heads (“Bales”). The study aims and procedures were fully explained in the local language (Yoruba) to all participants before the commencement of the study. Written informed consent or assent was obtained from all participants following health education sessions. In the case of children, additional written consent was obtained from their parents or guardians. All participants who tested positive for *S. haematobium* infection were treated with praziquantel 40 mg/kg (using the dose pole method). In addition, a community-wide mass drug administration (MDA) was carried out, during which other members of the communities, regardless of infection status, were also treated, as the areas were classified as high-risk for schistosomiasis transmission.

Authors' contributions: Christianah Folakemi Oki: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Funding Acquisition, Writing–Original Draft Preparation, Visualization, Project Administration. Olajumoke Abimbola Morenikeji: Conceptualization, Methodology, Investigation, Formal Analysis, Validation, Writing – Review & Editing, Supervision, Project Administration; Alexander Bababunmi Odaibo: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Validation, Writing – Review & Editing, Supervision, Funding Acquisition, Project Administration. All authors read, critically reviewed and approved the final version of the manuscript.

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Abbreviations

- UGS: Urogenital Schistosomiasis
- SSA: Sub-Saharan Africa
- MDA: Mass Drug Administration
- NTDs: Neglected Tropical Diseases
- WHO: World Health Organization
- LGA: Local Government Area
- PMF: Polycarbonate Membrane Filter
- PCR: Polymerase Chain Reaction
- No: Number
- Assoc: Association

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