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Original Article

Visual Diagnosis in Low-Resource Settings: Evaluating Urine Color and Macroscopic Haematuria as Rapid Indicators for Schistosoma haematobium Intensity

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Schistosoma haematobium, Visual Diagnosis, Haematuria, Urine Colour, Benue State, Rapid Assessment.

ABSTRACT

Urinary schistosomiasis, caused by Schistosoma haematobium, remains a significant public health burden in Nigeria, particularly in rural communities with limited access to diagnostic infrastructure. While urine filtration and microscopy remain the gold standard for diagnosis, they are often impractical in low-resource field settings. This study evaluates the diagnostic performance of visual indicators—specifically, urine colour and macroscopic haematuria—as rapid, low-cost proxies for determining infection intensity. A cross-sectional study was conducted across three locations in Makurdi, Benue State: North Bank, Agwan Jukun, and Jibata. A total of 1,032 participants were recruited and screened. Urine samples were examined macroscopically for colour and haematuria, and microscopically for S. haematobium eggs. Infection intensity was categorised as light or heavy based on egg counts. Statistical associations were analysed using Chi-square tests. The overall prevalence of urogenital schistosomiasis in the study area was 56.69% (585/1,032). Visual inspection revealed a strong correlation between urine appearance and infection intensity. Participants with "Bloody Red" urine had a 99.15% infection rate, with 77.97% of these cases classified as heavy infections. Similarly, the presence of haematuria (micro and macro combined) was associated with a 97.25% infection rate, with 64.19% of these cases being heavy infections. Self-reported bloody urine also showed a high diagnostic value, with 88.76% of symptomatic individuals testing positive. Visual diagnosis, particularly the observation of bloody urine and urine colour changes, serves as a highly reliable, rapid assessment tool for identifying heavy S. haematobium infections. In resource-constrained settings where microscopy is unavailable, these visual indicators can be effectively used to prioritise treatment and map high-risk communities.

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INTRODUCTION

Urogenital schistosomiasis, caused by the trematode *Schistosoma haematobium*, remains one of the most prevalent Neglected Tropical Diseases (NTDs) in sub-Saharan Africa. The disease disproportionately affects rural populations with limited access to clean water and sanitation, leading to chronic morbidity including anaemia, malnutrition, and bladder pathology (Gebrehana et al., 2024). Nigeria bears the highest burden of schistosomiasis in the region, with an estimated 29 million infected individuals (Odaibo et al., 2024). In endemic states like Benue, transmission is sustained by intense water contact activities in agricultural communities, where the disease is often neglected until severe complications arise (Odaibo et al., 2024).

The World Health Organization (WHO) currently recognises urine filtration followed by microscopy as the gold standard for diagnosing *S. haematobium* infection (Ally et al., 2024). This method allows for the direct visualisation and quantification of eggs, which is essential for determining infection intensity. However, microscopy is frequently impractical in low-resource field settings due to the requirement for electricity, expensive equipment, and trained laboratory personnel (Chala, 2023). Consequently, mass drug administration (MDA) campaigns often rely on broad prevalence estimates rather than individual screening, potentially missing high-risk individuals in unmapped "hotspot" communities (Sturt et al., 2023; Wami et al., 2014).

To bridge this diagnostic gap, rapid assessment tools are urgently needed. Visual inspection of urine for macroscopic haematuria (visible blood) and turbidity has been proposed as a low-cost alternative for identifying infected individuals. Previous studies suggest that macroscopic haematuria is not only a specific sign of *S. haematobium* infection but is also strongly correlated with heavy egg burdens (Murare & Taylor, 1987; Mott et al., 1983). For instance, Nwaorgu and Anigbo (1992) found that visual indicators could correctly identify heavy infections with high sensitivity. Despite this promise, the use of nuanced urine colour grading as a direct proxy for infection intensity has not been fully validated in the current epidemiological context of Benue State.

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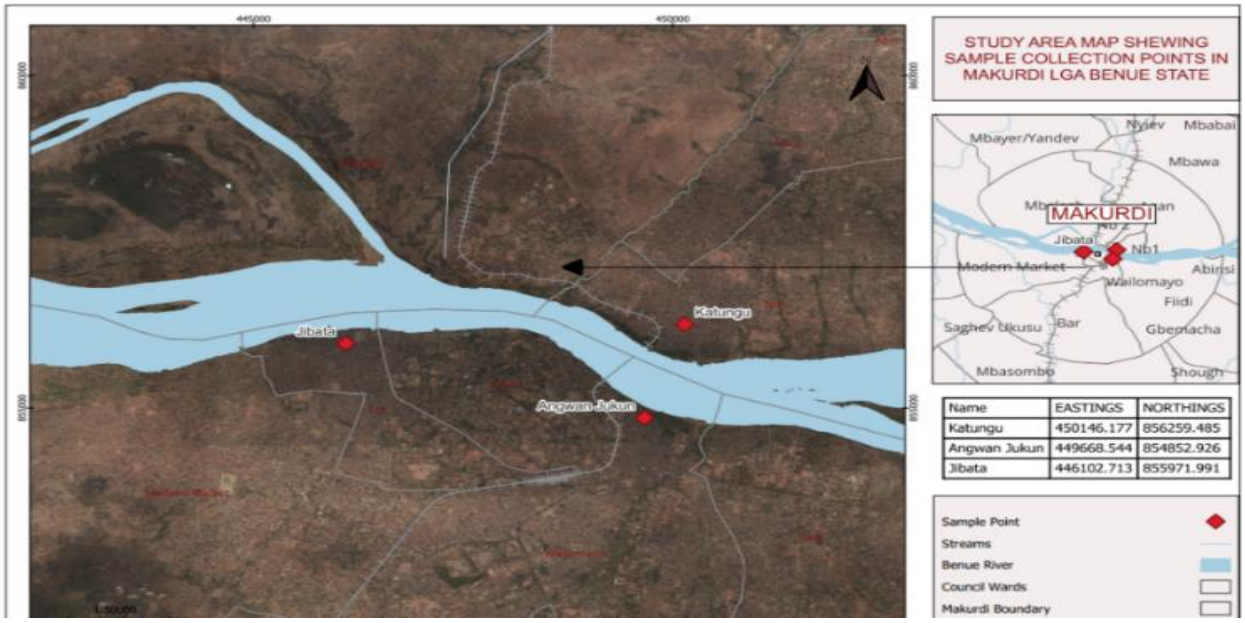
This study aims to evaluate the diagnostic performance of visual indicators—specifically urine colour and macroscopic haematuria—as rapid proxies for *S. haematobium* infection intensity. Specifically, the objectives of this study are to: 1) determine the prevalence and intensity of urinary schistosomiasis in the selected communities of Makurdi; 2) assess the relationship between visual urine indicators (color and haematuria) and microscopic egg counts; and 3) establish a simple, instrument-free visual diagnostic criteria that can be used by community health workers to prioritize high-risk patients for immediate treatment. By correlating visual findings with microscopic egg counts in a large cohort across three rural communities, we seek to establish a simple, instrument-free algorithm that can be used by community health workers to prioritise high-risk patients for immediate treatment.

MATERIALS AND METHODS

Study Area

The study was conducted in Makurdi, the capital of Benue State, Nigeria. Makurdi lies along the Benue River at latitude 07°43′N and longitude 08°35′E and serves as an administrative, commercial, and military hub, hosting a major Nigerian Air Force base (National Population Commision, NPC, 2006). Three specific communities were selected for this research: Katungu, Angwan Jukun, and Jibata (Figure 1). These locations were chosen due to their proximity to the Benue River and the high frequency of water contact activities among residents, which predisposes them to urogenital schistosomiasis.

Figure 1: Map of Makurdi Highlighting the Study Area



Study Design and Population

A cross-sectional study design was employed to assess the prevalence and intensity of *S. haematobium*. The study population consisted of individuals residing in the three selected communities: Katungu, Agwan Jukun, and Jibata. Participation was voluntary, and informed consent was obtained from all adult participants and guardians of minors.

Sample Size Determination

The sample size was determined using the formula for cross-sectional studies as described by Pourhoseingholi et al. (2013):

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$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where:

- **n** = Sample size required.
- **Z** = Z-statistic for a 95% confidence level (1.96).
- **P** = Expected prevalence. We utilised the recent prevalence of **23.8%** (0.238) reported by Okita et al. (2023) in a similar study conducted in Makurdi.
- **d** = Precision (margin of error). A precision of **5.0%** (0.05) was adopted for this study.

Substituting the values:

$$n = \frac{1.96^2 \times 0.238 \times (1-0.238)}{0.05^2} \sim 279$$

The calculated minimum sample size was 279. However, to ensure greater statistical power and account for potential attrition, a total of 344 participants were recruited from each of the three locations, resulting in a total study population of 1,032.

Ethical Approval

Ethical approval for the study was obtained from the Research and Ethics Committee of the Benue State Ministry of Health with ethical number MOH/STA/204/1/293. Written informed consent was obtained from all participants, and parental consent with participant assent was obtained for minors.

Sample Collection

Urine samples were collected between 10:00 AM and 2:00 PM to coincide with the peak circadian egg excretion of *S. haematobium*. Participants were provided with clean, wide-mouthed, leak-proof containers and instructed on how to collect urine.

Visual Diagnosis

Immediately upon collection, a macroscopic examination was performed. Samples were inspected for the presence of visible blood (macrohaematuria). Visual turbidity and colour were assessed and assigned numbers and grouped accordingly. 1–6. This scale categorised urine appearance into distinct profiles observed in the field, including Clear, Light Yellow, Light Brown, Dark Brown, Bloody Red, and Bloody Brown.

Microscopy

The definitive diagnosis and quantification of infection intensity were performed using the polycarbonate filtration technique. A standard volume of 10 mL of urine was drawn from each sample into a syringe. The urine was passed through a polycarbonate filter (12–20 µm pore size), which retains *S. haematobium* eggs while allowing urine to pass through.

The filter was then removed, placed on a glass slide, and examined under a light microscope. Eggs were counted and recorded as eggs per 10 mL of urine. Infection intensity was classified according to World Health Organization (WHO) guidelines:

- Light Infection: < 50 eggs/10 mL
- Heavy Infection: ≥ 50 eggs/10 mL (WHO, 2022)

Data Analysis

Data were entered into Excel and analysed using statistical software. Frequencies and proportions were calculated for prevalence rates. The Chi-square test was utilised to determine the association between visual indicators (urine colour, haematuria) and infection intensity. A P-value of less than 0.05 ($P < 0.05$) was considered statistically significant.

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RESULT

Overall Prevalence of Urinary Schistosomiasis among the Study Population.

Observations of urine colour were recorded from a total of 1032 subjects across the three locations sampled. Of these, 585 (56.69%) were positive for Schistosoma haematobium eggs using the filtration technique. There was a highly significant difference in infection rates across the three locations ($\chi 2$ = 639.11, P < 0.001). The community of Jibata recorded a prevalence of 100% (344/344), indicating a hyper-endemic status. Agwan Jukun followed with a prevalence of 59.30% (204/344), while North Bank had the lowest infection rate at 10.76% (37/344) (Table 1).

Table 1: Urogenital Schistosomiasis Infection in the Study Location

Location	Total Examined	No. Infected (%)
Katungu	344	37 (10.76%)
Agwan Jukun	344	204 (59.30%)
Jibata	344	344 (100.00%)
Total	1,032	585 (56.69%)

χ^2 = 639.11, df = 2, P<0.001

Prevalence of Urinary schistososmiasis based on Demographic of Study Participants

Demographic analysis revealed a significant gender disparity ($\chi 2$ = 21.05, df = 1, P<0.001), with females having a higher infection rate (62.73%) compared to males (48.26%). Age was also a significant risk factor ($\chi 2$ = 88.00, df = 3, P<0.001); the prevalence peaked in the 16–19 years age group (91.67%) and the 11–15 years age group (67.36%), confirming that school-aged children and young adults bear the highest burden of the disease (Table 2).

Table 2: Sex and Age-associated prevalence in the study location

Variables	No. Examined	No. Infected (%)	χ^2	P-Value
Sex				
Male	431	208 (48.26%)	21.05	<0.001
Female	601	377 (62.73%)		
Total	1032	585 (56.69%)		
Age Group (Yrs)				
1-5	122	36 (29.51%)	88.00	<0.001
6-10	479	247 (51.57%)		
11-15	383	258 (67.36%)		
16-19	48	44 (91.67%)		
Total	1032	585 (56.69%)		

Association of Urine Colour and Urinary Schistososmiasis Intensity

Urine was visually inspected and assigned a number (Figure 2). The urine colour chart ranges from 1 to 6, where

1 = clear urine

2 = Light yellow (normal colour of urine)

3 = Light-brown,

4 = Dark-brown (urine with visible haematuria)

5 =Bloody brown (urine with visible haematuria)

6 = Bloody Red (urine with visible haematuria)

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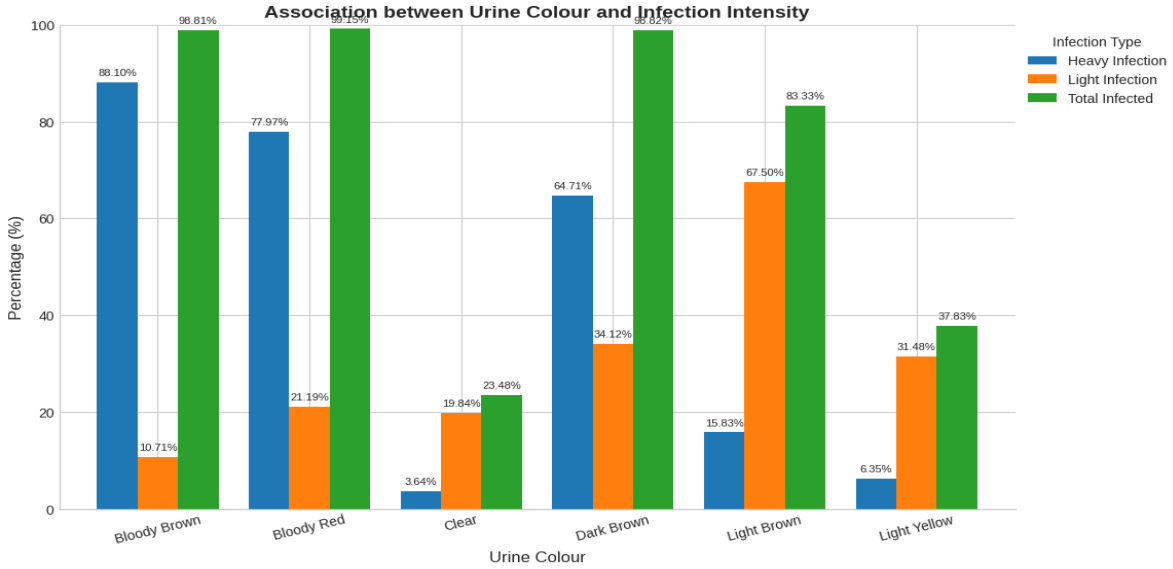
Figure 2: Urine Colour Chart Used for Classification

Urine colour served as a distinct rapid indicator for infection intensity ($\chi 2 = 224.96$, df = 5, $P < 0.001$). The study identified a clear risk based on visual appearance, as highlighted in Figure 3. Light yellow urine had 37.83% infection, with 6.35% heavy and 31.48% light. Clear urine showed 23.48% infection, including 3.64% heavy and 19.84% light. Light brown urine exhibited 83.33% infection, with 15.83% heavy and 67.50% light. Bloody red urine had 99.15% infection, comprising 77.97% heavy and 21.19% light. Dark brown urine showed 98.82% infection, with 64.71% heavy and 34.12% light. Bloody brown urine had 98.81% infection, including 88.10% heavy and 10.71% light. Visually darker or blood-tinged urine colours (bloody red, dark brown, bloody brown) were associated with higher infection rates and a greater proportion of heavy-intensity cases compared to lighter or clear urine.

Figure 3: Association between Urine Colour and Intensity of eggs/10ml Urine.



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$\chi^2 = 224.96$, df = 5, P < 0.001

Association between Haematuria and Schistosomiasis Prevalence Intensity

Visual examination of urine for haematuria demonstrated a strong association with both the presence of infection and the intensity of egg burden ($\chi 2 = 158.46$, P < 0.001) as shown in Table 3. Participants presenting with both micro- and macro-haematuria exhibited a remarkably high infection rate of 97.25% (353/363). Crucially, this group also displayed the highest proportion of heavy infections at 64.19%. Microhaematuria alone showed a 100% infection rate with 22.22% Heavy infection and 77.78% light infection. Urine with visible Blood (Macrohaematuria) showed a prevalence rate of 67.11%, of which heavy infection is 7.89% and light infection is 59.21%. Participants with the absence of Haematuria showed a low prevalence of 19.53%, of which heavy infection is 3.12% and light infection 16.41%.

Clinical Symptoms of Urinary Schistosomiasis among the Study Population

Symptoms associated with infection were evaluated; Bloody urine showed a significant relationship with Schistosomiasis infection rate (χ^2=316.32, df=1, P<0.001), with 88.76% infection amongst those who showed the symptom. Painful urination showed a significantly high prevalence of 77.38% (χ^2=269.85, df=1, P<0.001) among participants who reported the symptom. Frequent was also significant (χ^2=95.14, df=1, P<0.001) with 66.67% infected among the symptomatic group. Blood at the end of urination was also observed to be significant (χ^2=413.44, df=1, P<0.001) with 91.38% infection rate among the asymptomatic group as well. Itching after water contact should have a prevalence of 78.86%, and the relationship was significant as well (χ^2=174.91, df=1, P<0.001). These symptoms, particularly those visually observable, like bloody urine, demonstrated strong associations with infection presence as shown in Table 4.

Table 3: Association between Haematuria and Schistosomiasis Prevalence Intensity/10mL Urine

Haematuria	No. Examined	No. Infected (%)	Heavy Infection (%)	Light Infection (%)
Microhaematuria	81	81 (100%)	18 (22.22%)	63 (77.78%)
Macrohaematuria	76	51 (67.11%)	6 (7.89%)	45 (59.21%)
Both	363	353 (97.25%)	233 (64.19%)	120 (33.06%)
Absence of Haematuria	512	100 (19.53%)	16 (3.12%)	84 (16.41%)
Total	1,032	585 (56.59%)	273 (26.45%)	312 (30.23%)

$\chi^2 = 158.46$, df = 3, P < 0.001

Table 4: Prevalence of Schistosomiasis Based on Symptoms of the Infection

Symptoms	No. Examined	No. Infected (%)	χ^2	P-Value
Bloody Urine				
Yes	436	387 (88.76%)	316.32	<0.001
No	596	198 (33.22%)		
Total	1032	585 (56.69%)		
Painful Urination				
Yes	619	479 (77.38%)	269.85	<0.001
No	413	106 (25.67%)		
Total	1032	585 (56.69%)		

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Symptoms	No. Examined	No. Infected (%)	χ^2	P-Value
Urinating Frequently				
Yes	717	478 (66.67%)	95.14	<0.001
No	315	107 (33.97%)		
Total	1032	585 (56.67%)		
Blood at the end of urination				
Yes	464	424 (91.38%)	413.44	<0.001
No	568	161 (28.35%)		
Total	1032	585 (56.69%)		
Itching after contact with water body				
Yes	473	373 (78.86%)	174.91	<0.001
No	559	212 (37.92%)		
Total	1032	585 (56.69%)		

DISCUSSION

The study recorded an overall prevalence of 56.69% for urogenital schistosomiasis across the three communities, with Jibata recording a hyper-endemic rate of 100%. This overall prevalence is alarmingly high but consistent with the classification of Nigeria as a hyper-endemic nation for neglected tropical diseases. This finding agrees with a 2025 study in Kwara State, which confirmed that Schistosoma haematobium transmission remains persistent and intense in riparian communities despite control efforts (Opeyemi et al., 2025). However, the observed prevalence is significantly higher than the 13.6% reported in a 2025 community-based assessment in Northwestern Nigeria (Yelwa et al., 2025) and the 23.75% recorded in a 2023 study of primary school children in Makurdi (Okita et al., 2023). This stark contrast, particularly the 100% infection rate in Jibata, may be explained by the intense, focal transmission dynamics in communities located directly on the banks of the Benue River, where residents have no alternative to river water for all domestic and recreational needs.

The study observed a statistically significant gender disparity, with females having a higher infection rate (62.73%) compared to males (48.26%). This finding contrasts with the majority of recent epidemiological literature in Nigeria, which typically identifies males as the high-risk group due to swimming and fishing activities. For instance, a 2025 study in Kwara State reported higher infection intensity and prevalence in males (22.3%) compared to females (19%) (Opeyemi et al., 2025). Similarly, a 2023 study in the same locality (Makurdi) found males to be slightly more infected, attributing it to their adventurous water-contact behaviours (Okita et al., 2023). The higher prevalence among females in this specific study can be explained by the socio-cultural dynamics of the sampled communities (Katungu, Agwan Jukun, Jibata), where women and young girls bear the primary responsibility for fetching water, washing clothes, and processing food at the riverbanks, thereby sustaining longer and more frequent contact with infested water.

Infection prevalence peaked in the 16–19 years age group (91.67%), followed closely by the 11–15 years group (67.36%). This agrees with a 2023 study in Makurdi, which also identified the 16–20 age bracket as having the highest prevalence, attributing it to the cumulative exposure and peak

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water-contact activities of adolescents (Okita et al., 2023). Furthermore, a 2025 multivariate analysis in Northwestern Nigeria identified adolescents (10–14 years) as the group at highest risk for urogenital schistosomiasis (Yelwa et al., 2025). This pattern confirms that the burden of infection rises with age as children transition into adolescence and take on more independent roles in water-related activities, before potentially acquiring partial acquired immunity in later adulthood.

The study's finding that "Bloody" urine and macroscopic haematuria are highly specific indicators for heavy *S. haematobium* infection aligns with recent diagnostic evaluations in Nigeria. A 2025 study in Kwara State confirmed that macroscopic haematuria remains a robust proxy for high-intensity infections in resource-limited settings where microscopy is unavailable (Opeyemi et al., 2025). Similarly, a 2023 systematic review of diagnostic tools in sub-Saharan Africa affirmed that while microhaematuria (detected by reagent strips) has higher overall sensitivity, macroscopic haematuria (visible blood) offers superior specificity for identifying individuals with heavy egg burdens who require immediate treatment to prevent morbidity (Vere et al., 2025). The strong correlation observed in this study between darker urine colours (Bloody Brown/Red) and infection intensity further validates the use of simple urine colour charts as a rapid instrument for community health workers.

However, the diagnostic utility of visual inspection diminishes significantly in cases of light infection. While "Bloody Red" urine predicted infection with >99% accuracy, lighter urine shades (Clear/Light Yellow) still harboured infections, albeit mostly light ones. This limitation is consistent with a 2025 systematic review, which noted that visual diagnosis alone often misses up to 30-50% of light infections, particularly in post-treatment populations or low-endemicity areas where egg excretion is sporadic (Desale et al., 2025). Consequently, relying solely on visual symptoms may underestimate the true prevalence of disease in the community, leaving a reservoir of asymptomatic carriers who continue to sustain transmission.

Despite these limitations, the high positive predictive value of bloody urine observed in this study supports a two-tiered diagnostic strategy for rural Benue State. As suggested by recent operational research in 2025, visual screening can serve as a primary filter to identify "hotspot" households or individuals for immediate praziquantel administration, while resource-intensive microscopy or reagent strips can be reserved for asymptomatic individuals with clear urine (Desale et al., 2025). This approach optimises the use of scarce medical resources while ensuring that the most severe cases are prioritised for care.

The study found that self-reported "bloody urine" (haematuria) and "painful urination" (dysuria) were strongly associated with infection, with 88.76% of those reporting bloody urine testing positive. This agrees with a 2025 study in Bauchi State, which identified haematuria and dysuria as the most reliable self-reported morbidity markers for *S. haematobium* in endemic riparian communities (Aminu et al., 2025). Similarly, a 2024 survey in Osun State confirmed that haematuria (both macroscopic and microscopic) remains the primary clinical sign prompting diagnosis in school-aged children (Aniaguya et al., 2024). However, this contrasts with findings from low-endemicity settings where symptom-based diagnosis often has poor sensitivity due to the high prevalence of asymptomatic light infections. For instance, a 2023 study in Adamawa State noted that while haematuria was specific, it failed to identify a significant proportion of infected children who were asymptomatic but still shedding eggs (Zamdayu et al., 2023). The high rate of symptomatic morbidity observed in this study is likely explained by the chronic, high-intensity nature of transmission in these specific riverine communities, where repeated re-infection exacerbates bladder pathology and clinical symptom presentation.

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CONCLUSION

This study has demonstrated that urogenital schistosomiasis remains a hyper-endemic public health challenge in Makurdi, particularly in riverine communities like Jibata, where infection rates reached 100%. Our findings validate that visual diagnosis is a highly effective, rapid assessment tool for identifying heavy infection loads. Specifically, the observation of "Bloody Red" or "Bloody Brown" urine offers a diagnostic precision comparable to microscopy for high-intensity cases.

While visual inspection may miss light, asymptomatic infections, its ability to instantly identify the most severe cases makes it an invaluable triage tool for resource-constrained settings. We recommend the integration of simple urine colour charts into community-based surveillance programs in Benue State. This would empower local health workers to rapidly map hotspots and prioritise treatment for those at the highest risk of morbidity, ensuring that scarce medical resources are utilised where they are needed most.

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Conflict of Interest

The authors declare no conflict of interest.

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