Hyper-Endemicity of Urinary Schistosomiasis in Riverine Communities: A Comparative Study of Risk Factors and Water Contact Patterns in Makurdi

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Abstract*: Despite national control efforts, urinary schistosomiasis remains a recalcitrant public health challenge in Nigeria's Benue Trough. Current surveillance often overlooks the extreme micro-epidemiology of riverine "hotspots" where transmission dynamics defy general trends. This study investigated the hyper-endemicity of *Schistosoma haematobium* in Makurdi, aiming to unmask localized transmission drivers and seasonal risk factors. A comparative cross-sectional study was conducted among 1,032 participants across three riverine communities: Katungu, Agwan Jukun, and Jibata. Terminal urine samples were analyzed via filtration for *S. haematobium* eggs, and infection intensity was correlated with data from structured questionnaires regarding water contact behavior, sanitation, and seasonality. The study revealed a startling spatial heterogeneity. While the overall prevalence was 56.69%, the Jibata community recorded a "saturation prevalence" of 100.00% (344/344), marking it as a critical hyper-endemic focus compared to Katungu (10.76%). Challenging classical epidemiological models, females exhibited a significantly higher infection rate (62.73%) than males (48.26%) (P < 0.001), suggesting a shift in risk from recreational to domestic water contact. Infection peaked at 91.67% in the 16–19 age group. Risk analysis identified reliance on river water as the primary driver (88.84% prevalence), exacerbated by perennial transmission; participants active in both rainy and dry seasons faced the highest risk (66.07%). The absolute infection rate in Jibata indicates a total breakdown of sanitation barriers, identifying the community as a priority zone for emergency intervention. The study confirms that transmission in this axis is driven by occupational exposure and failed water infrastructure rather than mere recreation. Effective control must move beyond school-based treatment to include community-wide WASH implementation and targeted support for women and older adolescents.

***Keywords*: Urinary Schistosomiasis, Hyper-endemicity, Gender Paradox, Jibata Hotspot, Water Contact Patterns.**

1. Introduction

Urogenital schistosomiasis, caused by the digenean trematode *Schistosoma haematobium*, remains a neglected tropical disease (NTD) of immense public health consequence. Globally, the disease affects over 240 million people, with the vast majority of the burden concentrated in sub-Saharan Africa, where it ranks second only to malaria in terms of parasitic morbidity [1]. In Nigeria, the disease is endemic and widely distributed, particularly in rural and peri-urban communities where livelihoods are inextricably tied to freshwater bodies [8].

Despite decades of control interventions, Nigeria continues to report patchy transmission dynamics. Recent epidemiological surveys have categorized the country into zones of hyper-endemicity and moderate endemicity, often determined by the presence of the intermediate snail host *Bulinus* spp. and human water contact behaviors [5]. For instance, recent studies in Kebbi State have reported moderate-to-high prevalence rates of 49% among secondary school students, identifying fishing activities as a primary driver of transmission [5]. Similarly, research in Osun State linked specific water contact patterns to persistent infection, recording a prevalence of 31.9% among residents, with males significantly more affected than females [10].

In Benue State, the epidemiological picture is equally complex. The River Benue serves as a major transmission corridor, supporting high vector density and intense human interaction. While some recent studies in Makurdi have reported moderate prevalence rates of approximately 23.75% among primary school children [9], other surveys in nearby Local Government Areas like Guma have indicated much higher transmission rates, exceeding 50% in certain rural clusters [11]. Furthermore, recent co-infection studies in the Igede axis of Benue State have highlighted the double burden of malaria and schistosomiasis, with *S. haematobium* prevalence recorded at 14.6% even in areas under surveillance [2].

However, a significant gap remains in understanding the localized "hotspots" of hyper-endemicity where transmission

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does not follow the moderate national trend. Most existing studies focus on school-based populations and often overlook the comparative risk factors between specific riverine communities with varying degrees of water dependence. Additionally, the role of seasonality—specifically the variation in risk between dry and rainy seasons—remains under-reported in Makurdi, despite evidence from recent studies in Ebonyi State suggesting that snail infectivity and transmission potential fluctuate significantly between the dry and wet seasons [12].

Therefore, this study was designed to assess the hyper-endemic status of urinary schistosomiasis across three distinct riverine locations in Makurdi. By adopting a comparative approach, this research evaluates the specific influence of occupational factors (fishing versus farming), water contact patterns, and seasonal exposure on infection intensity, providing critical data to guide targeted eradication efforts in high-burden communities.

2. Materials and Method

A. Study Area

The study was conducted in Makurdi, the capital city of Benue State, located along the banks of the River Benue (Latitude 7°44' N, Longitude 8°32' E). The river traverses the city, dividing it into the Northern and Southern banks, and serves as the primary source of water for domestic, agricultural, and occupational activities for the inhabitants. The area is characterized by a tropical savannah climate with two distinct seasons: the wet season (April to October) and the dry season (November to March). These seasonal variations significantly influence water volume and human water contact behaviors [12]. Three distinct riverine communities were purposively selected based on their varying proximity to the river (Figure 1).

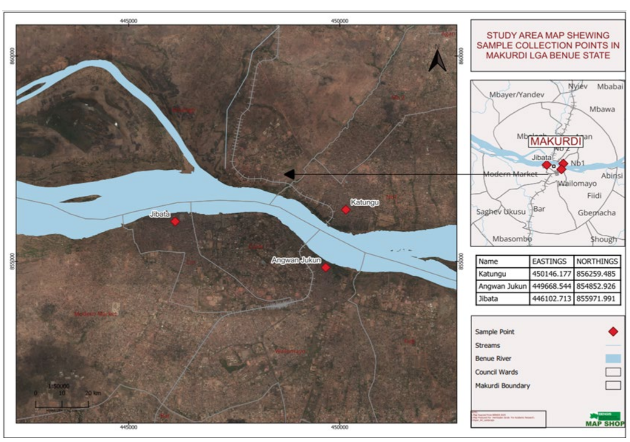

Fig. 1. A spatial map of Makurdi showing study area

B. Study Design and Population

A cross-sectional comparative study design was adopted to assess the prevalence and risk factors of urinary schistosomiasis. The study population comprised residents of the three selected communities, including school-aged children and young adults who are typically at the highest risk of infection.

C. Sample Size and Sampling Technique

A total of 1,032 participants were recruited for the study. To ensure statistical robustness for a comparative analysis, a uniform sample size was allocated to each of the three locations (n = 344 per site). A systematic random sampling technique was employed to select households within each community, and informed consent was obtained from all participants (or their parents/guardians) prior to enrollment.

D. Sample Collection

A structured questionnaire was administered to obtain demographic data and specific water contact behaviors. Terminal urine samples were collected between 10:00 AM and 2:00 PM in wide-mouthed, clean, screw-capped containers. This timing was strictly adhered to as it coincides with the peak circadian egg excretion of *Schistosoma haematobium* [9].

E. Laboratory Analysis

Urine samples were analyzed using the standard urine filtration technique. A 10 mL aliquot of each urine sample was passed through a polycarbonate filter (12 µm pore size) using a syringe. The filter was then removed, placed on a microscope slide, and stained with Lugol's iodine. The slides were examined under a light microscope (x10 and x40 objectives) for the presence of *S. haematobium* eggs. Infection intensity was classified according to World Health Organization (WHO) guidelines based on egg counts per 10 mL of urine:

Light Infection: < 50 eggs/10 mL

Heavy Infection: > 50 eggs/10 mL

F. Data Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 27.0. Chi-square tests were employed to determine the association between prevalence and categorical variables. A P-value of $P < 0.05$ was considered statistically significant.

3. Result

A. Prevalence of Urogenital Schistosomiasis by Location

The overall prevalence of urogenital schistosomiasis in the study area was 56.69% (585/1,032). A statistically significant difference was observed across the three locations ($\chi^2 = 639.11$, $P < 0.001$). Jibata community recorded a saturation prevalence of 100.00% (344/344), indicating hyper-endemicity. Agwan Jukun recorded 59.30%, while Katungu had the lowest prevalence at 10.76% as recorded in Table 1.

Table 1
Urogenital schistosomiasis infection in the study location

Location	NE	NI (%)
Katungu	344	37 (10.76%)
Agwan Jukun	344	204 (59.30%)
Jibata	344	344 (100.00%)
Total	**1,032**	**585 (56.69%)**

$\chi2 = 639.11$, df = 2, P<0.001 NE = number examined; NI = number infected

B. Sex and Age-Associated Prevalence

Demographic analysis revealed a significant association between infection and sex ($\chi^2 = 21.05$, $P < 0.001$), with females having a higher prevalence (62.73%) compared to males (48.26%). Infection rates also increased significantly with age ($\chi^2 = 88.00$, $P < 0.001$), peaking in the 16–19 years age group (91.67%) and recording the lowest rates in the 1–5 years group (29.51%).

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

Variables	NE	NI (%)	χ^2	P-Value
Sex				
Male	601	377 (48.26%)	21.05	<0.001
Female	431	208 (62.73%)		
Total	1032	585 (56.69%)		
Age Group				
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%)		

NE = number examined; NI = number infected

C. *Influence of Family Occupation on Infection*

Parental occupation was a significant risk factor ($\chi2 = 46.51$, $P < 0.001$). Participants from fishing families recorded the highest prevalence at 64.97%, followed by those from trading families (57.57%). Children from farming households had the lowest infection rate at 40.21%, while no infection was recorded among the few children of hunters (Figure 2).

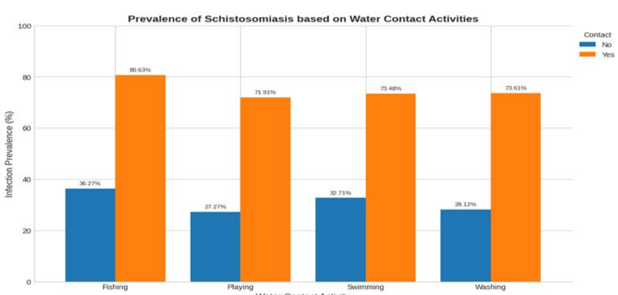

Fig. 2. Bar chart distribution showing prevalence of schistosomiasis based on water contact activities ($\chi2 = 46.51$, df = 4, $P<0.001$)

D. *Environmental Risk Factors (Urination Habits)*

A direct correlation was found between sanitation habits and infection. Participants who admitted to urinating in the river had a significantly higher infection rate of 80.24% compared to 25.62% among those who did not ($\chi^2 = 316.51$, $P < 0.001$).

Table 3
Schistosomiasis prevalence in respect to environmental factors and water contact activities

Variables	NE	NI (%)
Urinate In the River?		
Yes	587	471 (80.24%)
No	445	114 (25.62%)
Total	1032	585 (56.69%)

$\chi2 = 316.51$, df = 1, $P<0.001$ NE = Number Examined; NI = Number Infected

E. *Water Contact Activities*

Activity-specific analysis indicated that all assessed water contact behaviors were significantly associated with high infection rates ($P < 0.001$). Fishing carried the highest risk (80.63%), followed closely by washing (73.61%) and swimming (73.48%). Those who play in water bodies recorded a prevalence of 71.91%.

Table 4
Prevalence based on water contact activities

Activities	No. Examined	No. Infected (%)	χ^2	P-Value
Swimming				
Yes	607	446 (73.48%)	170.81	<0.001
No	425	139 (32.71%)		
Total	1032	585 (56.69%)		
Fishing				
Yes	475	383 (80.63%)	206.57	<0.001
No	557	202 (36.27%)		
Total	1032	585 (56.69%)		
Playing				
Yes	680	489 (71.91%)	208.57	<0.001
No	352	96 (27.27%)		
Total	1032	585 (56.69%)		
Washing				
Yes	648	477 (73.61%)	210.87	<0.001
No	384	108 (28.12%)		
Total	1032	585 (56.69%)		

Table 5
Prevalence of Schistosomiasis based on Knowledge, Attitude and Practices

Variable	No. Examined	No. Infected (%)	χ^2	P-Value
Reasons for passing bloody urine?				
Drinking dirty water	189	78 (41.27%)	14.76	0.0115
Playing in water bodies	133	95 (71.43%)		
Mosquito bites	53	36 (67.93%)		
Flies	77	45 (58.44%)		
Touching fresh water snails	356	177 (49.72%)		
Others	224	154 (68.75%)		
Total	1032	585 (56.69%)		
Which Season Do you most likely play in water bodies?				
Rainy Season	105	40 (38.10%)	108.57	<0.001
Dry Season	72	41 (56.94%)		
Both Rainy and Dry Season	725	479 (66.07%)		
None	130	25 (19.23%)		
Total	1032	585 (56.69%)		
Main source of water?				
Well	50	26 (52.00%)	358.32	<0.001
Tap	198	63 (31.82%)		
Borehole	363	122 (33.61%)		
River	421	374 (88.84%)		
Total	1032	585 (56.69%)		

F. Risk Factors Associated with Urinary Schistosomiasis Prevalence in Study Area

The results highlights that participants who correctly identified “Playing in water bodies” as the cause had the highest infection rate (71.43%). Misconceptions were prevalent and associated with high infection rates. Participants who attributed the disease to “Mosquito bites” (67.93%) and “Flies” (58.44%) were heavily infected, those who believed the cause was “Drinking dirty water” had the lowest relative prevalence (41.27%), those who believed “Touching water snails” showed infection rate of 49.72% while those who believed “Other” reasons showed a high prevalence of 68.75%.

There was a statistically significant association between participants perceived cause of bloody urine and their infection status ($x = 14.76$, $P = 0.0115$).

The study revealed a highly significant variation in prevalence based on the seasonal timing of water contact activities ($\chi^2 = 108.57$, $P < 0.001$). Participants who maintained contact with water bodies during both the Rainy and Dry seasons recorded the highest infection rate at 66.07%. Those who visited water bodies exclusively during the Dry Season had a higher prevalence (56.94%) compared to those who visited only during the Rainy Season (38.10%). Participants with no reported seasonal contact ("None") had the lowest prevalence at 19.23%.

The source of domestic water supply was highly significant ($\chi^2 = 358.32$, $P < 0.001$).

Dependence on the River for water supply was associated with an extremely high prevalence of 88.84%. Participants using Tap water (31.82%) and Boreholes (33.61%) recorded prevalence rates less than those relying on the river. Wells showed an intermediate prevalence of 52.00%.

4. Discussion

A. Prevalence and Hyper-endemicity of Urinary Schistosomiasis Among Study Population

The overall prevalence of urinary schistosomiasis observed in this study was 56.69%, classifying the study area as hyper-endemic according to World Health Organization (WHO) standards. This figure is alarmingly high but consistent with the patchy transmission dynamics characteristic of Benue State. The result aligns closely with recent findings by Orpin et al. [11], who reported a prevalence of 54.7% in the neighboring Guma Local Government Area (LGA), confirming that riverine communities in the Benue trough remain high-transmission zones. However, the prevalence recorded here is significantly higher than the 23.75% reported by Okita et al. [9] among primary school children in Makurdi township. This disparity likely reflects the specific "riverine" nature of the current study population; while Okita et al. sampled a broader urban/peri-urban demographic [9], the current study purposively targeted communities directly on the riverbank, where reliance on the river is absolute.

A defining finding of this study is the extreme spatial variation, ranging from 10.76% in Katungu to a saturation prevalence of 100.00% in Jibata. Such "hotspots" of total saturation are rare but not unprecedented in neglected tropical disease epidemiology. Similar spatial clustering was observed in Jigawa State by recent studies, where specific communities recorded significantly higher burdens due to proximity to irrigation or river sites (local prevalence of 49.2%) [6]. The 100% infection rate in Jibata suggests a complete breakdown of sanitation and a lack of alternative water sources, forcing the entire population into daily contact with infested water. This mirrors the high-risk "rural clusters" identified by Angwa et al. [1] in the Igede axis of Benue State, where infection persists despite control efforts due to intense local vector density.

B. Prevalence Based on Gender

Contradicting the classical epidemiological trend where males are disproportionately affected due to swimming and recreational habits, this study recorded a significantly higher prevalence in females (62.73%) compared to males (48.26%). This finding diverges from recent reports by Okita et al. [9] and Daniel et al. [3] in Adamawa State, both of whom found higher infection rates in males.

The reversal observed here can be explained by the specific water contact behaviors identified in the study. This hypothesis is supported by Oboh et al. [7], who similarly noted that in communities where domestic water contact is the primary exposure route, female prevalence often equals or exceeds that of males.

C. Prevalence Based on Age

Infection peaked in the 16–19 age group (91.67%). This is consistent with the age-prevalence curve reported by Okita et al. [9], who also observed peak infection in the 16–20 years cohort. While classic models suggest infection peaks in early adolescence (10–14 years), the shift to older adolescence in this study suggests that exposure is not merely recreational but occupational. The 16–19 age group is the active workforce for water-based livelihoods, including fishing and sand mining, leading to accumulated worm burdens that persist into young adulthood.

D. Knowledge About Schistosomiasis

This study revealed a complex relationship between knowledge and infection. A significant proportion of participants attributed bloody urine to misconceptions such as “Mosquito bites” (67.93% infected) and “Flies”. This aligns with recent findings by Isyaku & Okanlawon [5] in Kebbi State, who reported that misconceptions often conflate malaria and schistosomiasis vectors, leading to ineffective prevention strategies (e.g., using bed nets instead of avoiding river contact).

However, the most striking finding was that participants who correctly identified “Playing in water” as the cause had the highest infection rate (71.43%). This demonstrates a distinct “Knowledge-Practice Gap,” where awareness of the risk does not translate into preventive behavior. This phenomenon has been corroborated by Olusi et al. [13] in Osun State, who noted that in hyper-endemic riverine communities, water contact is often inevitable due to lack of alternative water sources, rendering “knowledge” insufficient for protection without infrastructural support. The high infection among those citing "Mosquito bites" further emphasizes the need for targeted Health Education to correct specific myths that deter the community from addressing the actual water-borne risks [2].

E. Seasonality Transmission

A critical contribution of this study is the assessment of seasonality. Participants who maintained water contact during "Both Rainy and Dry Seasons" had the highest prevalence (66.07%). This indicates perennial transmission, challenging the assumption that risk fluctuates drastically with rainfall. While snail densities often vary seasonally—peaking in the dry season when water becomes stagnant—recent ecological studies at Kiri Reservoir indicate that transmission sites can remain viable year-round if human water contact is constant [4]. In Makurdi, the recession of the River Benue during the dry season concentrates human populations into smaller, more infested pools, while the rainy season expands the water surface area; thus, those active in both seasons face a "double jeopardy" of exposure.

F. Water Sanitation and Hygiene (WASH)

The strong correlation between river water dependence (88.84%) and infection underscores the failure of WASH infrastructure in these locations. In contrast, tap water users had a significantly lower risk (31.82%). This reinforces the conclusion by Ubaka et al. in Ebonyi State, who argued that mass drug administration (MDA) alone is futile without the provision of potable water [12]. In Jibata, where prevalence is 100%, the data suggests that the river is the only available water source, making reinfection inevitable immediately after treatment.

5. Conclusion

This study conclusively establishes that riverine communities in Makurdi, particularly those on the southern bank, remain active reservoirs for urinary schistosomiasis transmission. With an overall prevalence of 56.69%, the area is classified as hyper-endemic. However, the discovery of a "saturation prevalence" of in the Jibata community unmasks a critical public health emergency that has likely been overlooked by generalized surveillance. This finding indicates a total collapse of sanitation barriers in Jibata, where reliance on the river is absolute and infection is inevitable.

Furthermore, this research challenges the conventional epidemiological profile of the disease in Nigeria. The significantly higher prevalence among females compared to males suggests a shift in risk dynamics from recreational exposure to domestic and occupational water contact. Coupled with the peak infection rate in older adolescents, these results imply that current school-based Mass Drug Administration (MDA) programs targeting younger children may be missing the most heavily infected segments of the population.

The study also confirms that transmission in this axis is perennial rather than seasonal, with the highest risk observed among individuals active during both rainy and dry seasons. The near-perfect correlation between river water usage and infection underscores that chemotherapy alone is insufficient. Sustainable elimination in Makurdi will require a two-pronged approach: immediate, community-wide praziquantel distribution in "hotspots" like Jibata, integrated with the urgent provision of boreholes to break the cycle of dependency on infested river water.

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