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Comorbidities with Urinary Schistosomiasis and Malaria in Makurdi, Benue State, Nigeria

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ABSTRACT

Background and Objective: Malaria and urinary schistosomiasis-individually or as co-infections-remain major public health concerns across Sub-Saharan Africa. Despite their overlapping transmission patterns, data on their co-occurrence in many Nigerian communities remain limited. This study assessed the prevalence of *Schistosoma haematobium* (S.h) and *Plasmodium falciparum* (P.f) infections and their coinfections in selected communities of Makurdi, Benue State. **Materials and Methods:** A cross-sectional survey was conducted among 600 consenting participants from Angwan-Jukun, Agboughul, and Ijaha. Demographic information was obtained through structured questionnaires. Urine and blood samples were collected following standard protocols. P.f infection was detected using the CareStart rapid diagnostic test, while S.h ova were identified using the polycarbonate membrane filtration technique. All samples were analyzed at the Benue State University Zoology Laboratory. Data were processed using Chi-square statistics to determine associations between infection prevalence and demographic variables, with the level of statistical significance set at $p<0.05$. **Results:** Overall infection prevalence was 250/600 (41.6%), comprising S.h 129/600 (21.5%), P.f 75/600 (12.5%), and coinfections 46/600 (7.7%). Prevalence varied significantly across the three communities ($p<0.05$). No significant association was found between sex and infection status ($p>0.05$), although males showed slightly higher infection frequencies (S.h 49.6%; P.f 30.2%; coinfections 20.2%) than females (S.h 53.7%; P.f 29.8%; coinfections 16.5%). The highest S.h prevalence occurred in participants aged >65 years (4/5; 80.0%), while those aged 55-64 years recorded the highest P.f prevalence (4/5; 80.0%), with no coinfections in these groups. Educational status was significantly associated with infection prevalence ($p<0.05$). **Conclusion:** The study reveals a substantial burden of S.h, P.f, and their coinfections in Makurdi, influenced by demographic and educational factors. The findings highlight ongoing risks of overlapping parasitic infections in endemic communities and underscore the need for integrated control strategies and strengthened community health education.

KEYWORDS

Schistosoma haematobium, *Plasmodium falciparum*, coinfection, urinary schistosomiasis, Malaria, prevalence, Makurdi, Benue State, parasitic infections, public health

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INTRODUCTION

Malaria and schistosomiasis remain two of the most significant parasitic diseases of global public health importance, contributing substantially to morbidity and mortality worldwide[1,2]. Sub-Saharan Africa (SSA) bears more than 90% of the global burden of these infections, where concurrent malaria–schistosomiasis co-infections are frequently reported[3]. Such co-infections are especially common in rural communities and are closely associated with poverty and inadequate access to healthcare and sanitation[1,4].

Plasmodium falciparum is responsible for over 99% of malaria cases in SSA. Although five *Plasmodium* species infect humans, *P. falciparum* predominates across the region. The main malaria vectors in Africa include *Anopheles arabiensis*, *An. gambiae* sensu stricto (s.s.), and *An. Funestus*, each adapted to distinct ecological niches. Of these, *An. Funestus* and *An. gambiae* s.s. are highly anthropophilic, endophagic, and bite predominantly from dusk to dawn. Over the past two decades, significant advances in malaria control have been achieved through the scale-up of long-lasting insecticidal nets (LLINs), rapid diagnostic tests, and artemisinin-based combination therapies[1], with LLINs forming the backbone of vector control strategies. Between 2004 and 2020, more than two billion insecticide-treated nets, including LLINs, were distributed, and currently an estimated 65% of households in SSA own at least one LLIN[1].

Urogenital schistosomiasis, caused by *Schistosoma haematobium*, also remains a major public health concern. Globally, approximately 240 million people across 78 countries are infected, with Africa accounting for ~85% of cases[5]. Of the five *Schistosoma* species infecting humans, *S. haematobium* and *S. mansoni* are the most prevalent in SSA, including Nigeria, where they are responsible for urogenital and intestinal schistosomiasis, respectively[5]. The clinical burden of schistosomiasis in Africa is considerable: An estimated 150,000 deaths annually result from kidney failure linked to *S. haematobium*, while *S. mansoni infection* is associated with nearly 130,000 annual deaths from hematemesis due to portal hypertension[6]. Control strategies in Nigeria have primarily relied on mass drug administration (MDA) of praziquantel (PZQ) targeting school-aged children (SAC), implemented nationally and sub-nationally. Nonetheless, schistosomiasis remains endemic across all 36 states and the Federal Capital Territory[7].

In Benue State, previous investigations have documented urogenital schistosomiasis prevalence ranging from 23.0% to 55.4% across multiple Local Government Areas, including Makurdi, Buruku, Katsina-Ala, Ogbadibo, and Guma[8,9]. Despite this evidence, data on malaria–schistosomiasis interactions remain limited, particularly in Nigeria. This gap underscores the importance of the present study, which, to our knowledge, is the first to investigate *S. haematobium* and *P. falciparum* co-infections in this area. Findings from this work provide critical insights into the epidemiology of dual infections and may inform local health authorities in refining integrated control strategies.

MATERIALS AND METHODS

Study area: The study was conducted in three communities: Angwan Jukun (Latitude 7.733977, Longitude 8.54291), Agboughul (Latitude 7.7301361, Longitude 8.4865667), and Ijaha (Latitude 7.7408604, Longitude 8.4992064), all located in Makurdi, Benue State, Nigeria. These locations were chosen due to their proximity to the Benue River, which serves as a water source for both economic and recreational activities of some inhabitants of the study area. This hypothetically supports the transmission of schistosomiasis and malaria individually and as co-infections. The study spanned from November 2024 to March 2025. Benue State is geographically located on latitude of 7.74°North and a longitude 8.51°East and has an elevation of 104 m above sea level. The mean monthly rainfall ranges from 150 mm to 180 mm, and the mean monthly temperature ranges from 27°C to 38°C. Makurdi, the state capital is located along the bank of the Benue River, which serves as the predominant water source for anthropogenic activities of its inhabitants. It is characterized a typical high tropical climate with two clearly

marked seasons: Rainy season which is prolonged and starts from the month of April to October and the dry season that begins in late October and ends in March. Makurdi inhabitants are mostly civil servants and locals who engage in activities such as regular and irrigation farming, fishing, trading and rustling of ruminant animals.

Ethical consideration and consent: The study procedure was reviewed and approved by the Ethical Review Board of Benue State Ministry of Health, Makurdi. Before the commencement of the study, oral and written consent was sought from the community heads as well as the study participants. Only participants between the ages of 5 years and above whose parents/guardians gave consent and were willing to take part in the study, were enrolled.

Questionnaire administration: The subjects were those who consented to the study and suitable questionnaires were used to document the demographic data of the participants as well as other information relevant to the study. Where necessary, translations were made in the participants indigent languages to facilitate accurate documentation of the study data.

Collection of urine and blood samples: One Urine and blood sample each was collected from the study participants. Following standard procedures, urine samples were collected into 40 mL wide-mouthed plastic containers that were labelled with identification codes. Samples were collected between 10.00 am to 2.00 pm, the period when peak excretion of eggs is expected[8], and transported to the laboratory in black polythene bags, placed on ice packs. About 3 mL of venous blood samples were collected into EDTA bottles with the help of community health workers. The samples were labelled with the same codes on the questionnaire and urine sample bottles of the participants. Both urine and blood samples were transported to the Benue State University Zoological Laboratory for parasitological analysis.

Parasitological analysis of samples: The filtration technique using polycarbonate (PCTE) membrane filters (12.0 micron, 13 mm and 100/pk) by Sterlitech Corporation and the procedure previously described was used to screen for the presence of *S. haematobium* eggs in the urine samples. Samples with one or more oval eggs with terminal spine characteristic of the parasite were classified as positive[9].

The blood samples were screened for the presence of *P. falciparum* using the Care Start™ malaria rapid diagnostic kit (manufactured by Access Bio, Inc. USA) and following the manufacturer's instructions. The test was recorded as positive if 2 coloured lines appeared on the result window: 1 on the control (C) region and 1 on the test (T) region.

Data analysis: Study data was subjected to Chi-square at 95% confidence interval and a probaility level of 0.05, to determine associations between urinary schistosomiasis, *Plasmodium falciparum* and their coinfection prevalence and study variables. Infection prevalence was defined as the number of infected subjects with *S. haematobium, P. falciparum* or both, over the total number of screened participants. Urinary schistosomiasis intensity was classified as "light" for >50 eggs/10 mls of urine and "heavy" for <50 eggs/10 mls of urine[9].

RESULTS

A total of 250 persons were infected from the 600 participants enroled for the study resulting in an infection prevalence of 41.67%. infections were significantly associated with sampled locations. Angwan Jukun was the most infected 104/200 (52.00%), followed by Ijaha 100/200 (50.00%) and Agboughul 46/200 (23.00%) being the least. *Schistosoma haematobium* infections prevalence was 129/600 (21.50%) and the highest rate was recorded in Ijaha 64/200 (32.00%), followed by Angwan Jukun 48/200 (24.00%) and Agboughul 17/200 (8.50%). out of the 75/600 (12.50%) infections with *P. falciparum*, location-based

Table 1: Location-based prevalence of infections in the study area

Location	No. examined	No. infected (%)	*S. haematobium* (%)	*P. falciparum*+ve (%)	*S. haematobium*+ *P. falciparum* (%)
Angwan Jukun	200	104 (52.00)	48 (24.00)	39 (19.50)	17 (8.50)
Agboughul	200	46 (23.00)	17 (8.50)	21 (10.50)	08 (4.00)
Ijaha	200	100 (50.00)	64 (32.00)	15 (7.50)	21 (10.50)
Total	600	250 (41.67)	129 (21.50)	75 (12.50)	46 (7.67)
χ^2			33.832	14.263	6.263
p-value			0.001	0.001	0.044

Table 2: Relationship between participants' demographics and infection prevalence in the study area

Demography	No. positive (%)	S. h+ve (%)	P. f+ve (%)	S. h+P. f (%)
Sex				
Male	129	64 (49.6)	39 (30.23)	26 (20.16)
Female	121	65 (53.72)	36 (29.75)	20 (16.53)
Total	250	129 (21.50)	75 (12.50)	46 (7.67)
χ^2		0.422	0.007	0.547
p-value		0.516	0.934	0.460
Age group (years)				
5-14	128	66 (51.56)	44 (34.38)	18 (14.06)
15-24	54	34 (62.96)	11 (20.37)	09 (16.67)
25-34	33	14 (42.42)	08 (24.24)	11 (33.33)
35-44	14	07 (50.00)	03 (21.43)	04 (28.57)
45-54	11	03 (27.27)	04 (36.36)	04 (36.36)
55-64	05	01 (20.00)	04 (80.00)	00 (0.00)
≥65	05	04 (80.00)	01 (30.00)	00 (0.00)
Total	250	129 (21.50)	75 (12.50)	46 (7.67)
χ^2		184.806	100.600	5.304
p-value		0.001	0.001	0.151
Educational status				
Non-formal	53	27 (50.94%)	13 (24.53)	13 (24.53)
Primary	145	76 (52.41%)	46 (31.72%)	23 (15.86%)
Secondary	46	23 (50.00%)	14 (30.44%)	09 (6.21%)
Tertiary	06	03 (50.00%)	02 (33.33%)	01 (16.67%)
Total	250	129 (21.50)	75 (12.50)	46 (7.67)
χ^2		0.101	0.997	2.001
p-value		0.992	0.802	0.572

Data are presented as frequency (n) and percentage (%). S.h: *Schistosoma haematobium* positive, P.f: *Plasmodium falciparum* positive, S.h+P.f: Co-infection of *Schistosoma haematobium* and *Plasmodium falciparum* and χ^2: Chi-square test statistic used to assess associations between demographic variables and infection prevalence, A $p<0.05$ was considered statistically significant. Percentages in parentheses indicate the proportion of positive cases within each demographic category and +ve: positive

distribution in ascending order of prevalence were 19.50%, 10.50% and 7.50% in Angwan Jukun, Agboughul and Ijaha, respectively. Different degrees of mixed infections with both parasites were documented in the study Table 1.

The sex and educational status of the study participants were not significantly associated with single and mixed infections with *S. haematobium* and *P. falciparum* ($p>0.05$), Table 2. *Schistosoma haematobium* infection was higher in females, while *P. falciparum* and mixed infections with both parasites were slightly higher in males, Table 2.

In addition, age group >65 years (80.00%) were the most infected with S. *haematobium* ($p = 0.001$), while 55-64 years (80.00%) were the most infected with *P. falciparum* ($p = 0.001$). The highest mixed infections prevalence was recorded in the age group 45-54 years (36.36%) ($p>0.05$), Table 2.

Varying rates of mixed and infections with S. *haematobium* and *P. falciparum* were seen across the educational strata of the study participants ($p>0.05$), Table 2.

DISCUSSION

The prevalence of *S. haematobium, P. falciparum*, and co-infections was 21.50%, 12.50%, and 7.70%, respectively. The *S. haematobium* rate observed is comparable to that reported[9] but exceeds values previously documented in the study area[8,10,11] . Considerable variation has also been reported across Nigeria, ranging from 5.20% and 23.20% in Adamawa[12,13], 32.60% and 40.00% in Osun[14,15], 67.30% in Jigawa[16], 29.70% in Bauchi[17], 11.30% and 31.60% in Nasarawa[18,19], and 13.00% in Katsina[20].

Despite annual mass drug administration (MDA) campaigns with praziquantel targeting school-aged children (SAC), *S. haematobium* infection persists in the study area. This persistence may be explained by the fact that the present study was community-based, whereas the World Health Organization's (WHO) MDA coverage primarily targets schools. Additionally, high rates of absenteeism among SAC in peri-urban settings may lead to many children missing treatment opportunities[21] highlighted that MDA coverage often falls short of the WHO-recommended 75-100% benchmark, and that reduced praziquantel efficacy, whether due to resistance, under-dosing, or suboptimal treatment alongside absenteeism, may undermine control efforts. These challenges, compounded by poor water, sanitation, and hygiene (WASH) conditions in the study area, likely undermine control efforts and contribute to ongoing transmission.

The 12.5% prevalence of *P. falciparum* recorded in this study also diverges from average annual malaria rates across some Nigerian states: Lagos (10.00%), Delta (12.00%), Rivers (15.00%), Kogi (22.00%), Benue (28.00%), Kaduna (30.00%), Kano (35.00%), and Borno (40.00%)[22]. Malaria transmission is highly seasonal, with peaks during the rainy season when favorable breeding conditions for Anopheles mosquitoes coincide with environmental and socio-behavioral drivers of transmission. The present survey was conducted between November 2024 and March 2025, corresponding to the dry season, when reduced vector breeding opportunities likely contributed to the lower prevalence observed. Variability may also arise from differences in sample size, population characteristics, and diagnostic methods, as molecular assays offer greater sensitivity than the rapid diagnostic test used in this study.

Asymptomatic carriers of *S. haematobium* and *P. falciparum* constitute infection reservoirs, making the 7.7% co-infection prevalence a public health concern. Lower co-infection rates have been reported in Dutse, Nigeria (3.3%)[23] and other African settings, including Tanzania (1.6%)[24], Ghana (1.4%)[25], Rwanda (0.7%)[26], Uganda (0.2%)[27], and Senegal (0.7%)[28]. Conversely, considerably higher prevalence (16.9-88.4%) has been documented in Uganda and Tanzania[29,30]. Co-infection rates in Ghana are comparable to those in the present study[21].

Interactions between *S. haematobium* and *P. falciparum* may modulate host immune responses. While *S. haematobium* infection has been associated with persistent immune stimulation that may confer protection against uncomplicated malaria[22], evidence also suggests that schistosomiasis may impair antimalarial immunity, increasing susceptibility and severity of malaria, particularly among children[31]. In addition, variations in demographic (age, gender, health status), environmental and socio-economic (access to healthcare, sanitation and education) factors may be responsible for heterogeneity of *S. haematobium* and *P. falciparum* co-infection prevalence and patterns across different populations[32].

Sex was not significantly associated with infection prevalence in the present study; however, females exhibited slightly higher rates of *S. haematobium* infection, while males showed greater prevalence of *P. falciparum* and co-infections. Similar patterns of elevated *S. haematobium* infection among females have been reported in South-Western Nigeria[33]. In contrast, several studies have documented higher infection rates among males[9,14,16,18-20,22]. Similarly, research in Ghana documented that females had a lower risk of *S. haematobium* infection than males, attributing this to gender-specific roles that increase male exposure to cercariae-infested water[21].

Cultural norms governing gender roles in Africa, however, are not static and vary regionally. In the present study area, overlapping livelihood activities such as farming, fishing, recreation, and domestic water use likely create comparable exposure risks for both sexes. This cross-pollination of gender roles may explain the absence of a clear sex-based pattern of schistosomiasis prevalence in this population.

Single infections with *S. haematobium* and *P. falciparum* were associated with the ages ≥65 years and 55-64 years of the study populations, respectively. *S. haematobium* infection prevalence has been reported to peak at between 8-15 years[18,20,33] but contrasting findings have been reported in ages 5-9 years[12,16]. Typically, urogenital schistosomiasis exhibits a characteristic ageprevalence profile with peak infection prevalence and intensity in school-aged children (approximately 8-15 years), while *P. falciparum* clinical burden is concentrated in young children and asymptomatic carriage is most common in school-age groups; moreover, modelling and empirical studies indicate that the modal age of malaria infection shifts toward older ages as transmission intensity declines[34,35].

These established patterns contrast with the unexpected peak in adults ≥55 years observed in our survey and suggest alternative explanations such as community (rather than school-based) sampling frames, persistent chronic schistosome infections in older adults, occupation- or livelihood-related exposure, seasonal or micro-ecological factors, and diagnostic or sampling biases[35]. Citing the WHO malaria burden data and recent studies on asymptomatic carriage support the notion that local reductions in transmission and heterogeneity in exposure can alter age distributions, and therefore our finding likely reflects site-specific epidemiology rather than a generalizable shift in age-risk for these infections[36].

The observation that educational status did not significantly influence the risk of single or co-infection with *Schistosoma haematobium* and *Plasmodium falciparum* in this study aligns with evidence from several investigations in Nigeria and other endemic regions, although contrasting results have also been documented. For example, research demonstrated that parasitic infections often persist irrespective of educational attainment, with environmental exposure, community water contact behaviors, and local vector ecology serving as more critical determinants than education alone[37]. Similar conclusions have been reported in Tanzania, where ecological and occupational factors outweighed formal education in shaping infection risk[38]. Evidence from Uganda also suggests that socioeconomic and environmental conditions, rather than educational level, are stronger predictors of schistosomiasis and malaria transmission dynamics[39]. This suggests that while general educational attainment may not provide direct protection, integrated health education initiatives embedded within malaria and schistosomiasis control frameworks can foster behavior change and enhance compliance with preventive measures such as bed-net use, safe water practices, and participation in mass drug administration campaigns.

Overall, these findings underscore the importance of adopting comprehensive and multifaceted intervention strategies that combine environmental management, vector control, regular MDA, and culturally tailored health education. Such integrated approaches are more likely to sustainably reduce the burden of malaria and schistosomiasis in endemic communities than reliance on education or chemotherapy alone[37,39].

CONCLUSION

These findings demonstrate that *S. haematobium* and *P. falciparum* persist in peri-urban communities of Benue State despite ongoing interventions. School-based MDA alone may be insufficient, as it overlooks high-risk adult populations and misses children absent during treatment. Strengthening community-wide MDA, expanding praziquantel coverage, enhancing malaria vector control, and improving WASH infrastructure are crucial. Given the unusual age distribution and notable co-infection prevalence, integrated surveillance and interventions tailored to local epidemiology are needed. Such approaches will accelerate progress toward the WHO 2030 elimination targets for schistosomiasis and malaria.

SIGNIFICANCE STATEMENT

This study provides important evidence on the burden and epidemiology of *Schistosoma haematobium*, *Plasmodium falciparum*, and their co-infections in Makurdi, Benue State, Nigeria. The findings highlight persistent transmission despite ongoing interventions and emphasize the need for integrated community-based control strategies, improved health education, enhanced surveillance, and strengthened water, sanitation, and hygiene measures.

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