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Prevalence, Geographical Distribution and Risk Factors of Urinary Schistosomiasis, Bacteriuria and their Co-Infection among School-Aged Children, Kano, Nigeria

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Almajiri, Bacteriuria, Co-infection, Kano State, Risk factors, *Schistosoma haematobium*.

ABSTRACT
Urinary schistosomiasis and bacterial urinary tract infection frequently coexist in children, yet community-based data from northern Nigeria are scarce. This cross-sectional study determined the prevalence, geographical distribution and risk factors of *Schistosoma haematobium* infection, bacteriuria and their co-infection among school-aged children in Kura, Dambatta and Wudil Local Government Areas (LGAs) of Kano State. Using multistage sampling, 3,030 pupils (1,010 per LGA) from public primary, Islamiyya and Almajiri schools were enrolled between June 2024 and September 2025. A questionnaire captured socio-demographic, environmental and behavioural data. Terminal urine was examined microscopically for *S. haematobium* eggs and cultured for bacteria. Associations were tested using Chi-square tests and crude odds ratios. Of the 3,030 pupils, 670 (22.1%) had *S. haematobium* infection alone, 484 (16.0%) had bacteriuria alone, 183 (6.0%) had both infections and 1,693 (55.9%) had neither. Children form Kura recorded the highest prevalence of *S. haematobium* (26.3%) and bacteriuria (18.8%), followed by Dambatta and Wudil (both $p < 0.001$), whereas co-infection did not differ significantly between LGAs (5.2–6.9%; $p = 0.243$). Use of river or stream water, open defecation, frequent water contact, Almajiri school attendance and inadequate handwashing were all significantly associated with infection ($p < 0.001$), and frequent water contact showed the steepest gradient (22.1% of uninfected pupils compared with 100% of co-infected pupils). Urinary schistosomiasis and bacteriuria are common among pupils in Kano State with shared environmental and behavioural drivers. Integrated control that combines Praziquantel treatment, improved water, sanitation and hygiene, health education and urine culture-based surveillance is recommended.

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INTRODUCTION

Schistosomiasis is one of the most important neglected tropical diseases (NTDs). Sub-Saharan Africa carries most of the global burden, with an estimated 192 million cases, making up about 93% of the world total (Hotez & Kamath, 2009), and more than 250 million people are infected worldwide (LoVerde, 2024). Nigeria is considered the epicentre of the disease in Africa, and children bear a disproportionate share of the infection because of frequent contact with contaminated freshwater during play, bathing

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and household chores (Auta *et al*., 2020). Urinary schistosomiasis is caused by *Schistosoma haematobium*, which is acquired when cercariae shed by infected freshwater snails penetrate the skin. The adult worms settle in the venous plexus around the bladder, and the eggs they lay damage the bladder wall and are passed in urine, often with blood (Barsoum, 2013; CDC, 2019) Dams and irrigation schemes can enlarge snail habitats and so sustain transmission (Sule *et al*., 2025).

Urinary schistosomiasis often occurs together with bacterial urinary tract infection. Egg-induced injury to the urinary epithelium is thought to give bacteria access to the underlying tissue, and parasite-driven immune modulation may further reduce the host's ability to control bacterial infection (Barsoum, 2013; Ossai *et al*., 2014; Mbanefo *et al*., 2020). Co-infection can worsen morbidity and complicate treatment, but control programmes usually target the parasite alone and give little attention to concurrent bacteriuria (Kone *et al*., 2022). In Nigeria, studies of bacteriuria in urinary schistosomiasis have been reported from Ondo, Enugu, Taraba, Cross River and Katsina States (Ossai *et al*., 2014; Dada &Alagha, 2021; Kone *et al*., 2022; Alabi *et al*., 2023; Elkana *et al*., 2024; Ubi *et al*., 2024), and schistosomiasis has also been documented among patients with urinary tract infections in Bauchi and Azare (Sambo *et al*., 2024; Magaji *et al*., 2025). Community-based data from Kano State, where irrigation agriculture is widespread and infection has historically been highly endemic (Duwa *et al*., 2009), remain sparse.

Children attending Almajiri (Tsangaya) schools are a group of particular concern. They often live and bathe in poor sanitary conditions with limited access to safe water, and earlier work in Katsina State has shown high vulnerability to urinary schistosomiasis in this population (Alabi *et al*., 2023; Auta *et al*., 2024). Understanding how schistosomiasis, bacteriuria and their co-infection are distributed across locations and risk groups is a prerequisite for integrated control (O'Ferrall *et al*., 2024). This study therefore determined the prevalence and geographical distribution of *S. haematobium* infection, bacteriuria and their co-infection among school-aged children in three LGAs of Kano State, and identified the socio-demographic, environmental and behavioural factors associated with the infection.

MATERIALS AND METHOD

Study Area

The study was conducted in Kura, Dambatta and Wudil LGAs of Kano State, north-western Nigeria (Figure 1). Dambatta lies between latitudes 12°25'N and 12°42'N and longitudes 8°38'E and 8°44'E, about 49 miles north of Kano City, and covers roughly 732 km^2 (Jibril *et al*., 2022). Its population was 207,968 as at the 2006 census (National Population Commission, 2006). Wudil lies about 35 km south-east of Kano metropolis, between latitudes 11°45'N and 11°50'N and longitudes 8°49'E and 8°53'E, and had 185,189 inhabitants in 2006. Its economy rests mainly on agriculture, fishing and small-scale trading. Kura covers 206 km^2, had 144,601 inhabitants in 2006, is crossed by the Kura river and is one of the most extensively irrigated LGAs in the State, with farming as the main occupation. The area has a tropical savanna climate with a long hot dry season and a shorter wet season.

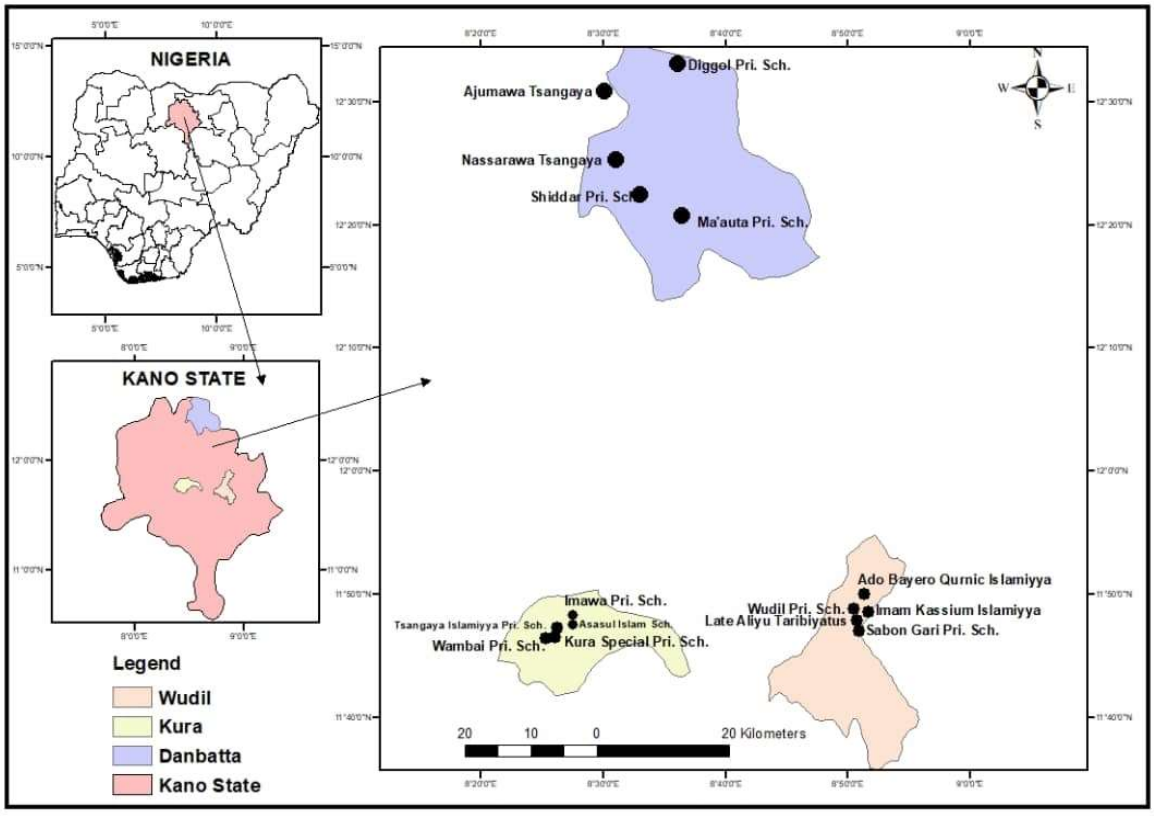


Figure 1: Map of Kano State showing the study LGAs and schools.
Source: GIS Laboratory, Federal University Dutsin-Ma.

Study Design and Ethical Approval

A descriptive cross-sectional design was used. Data and samples were collected between June to September in 2024 and 2025, when schools were in session and the rainy season favoured water-contact activities. Ethical approval was obtained from the Kano State Ministry of Health (NHREC/17/03/2018), the State Universal Basic Education Board (SUBEB) and the Kano State Ministry of Education. Advocacy visits were made to Local Government Area authorities, traditional rulers and head teachers, and permission was obtained from the Parent-Teacher Associations of participating schools. Written informed consent were obtained from the parents or guardians of all the participants.

Study Population, and Determination of sample Size

The study population comprised pupils of public primary (formal), Islamiyya and Almajiri (informal) schools. Pupils whose parents or guardians gave written consent were included irrespective of age. Pupils were excluded if consent was not given, if they were absent on the day of sampling, if they were too ill to participate, or if they did not complete the questionnaire or provide an inadequate volume of urine sample. Pupils who had taken antibiotics in the preceding weeks (which could suppress bacterial growth) and those who had received Praziquantel through mass drug administration in the preceding year (which could lower egg output) were also excluded.

The minimum sample size per LGA was determined using Cochran's single-proportion formula at 95% confidence and 5% precision, based on a previously reported prevalence of 82% in Kano State with a 10% allowance for non-response. This gave 1,010 pupils per LGA and 3,030 pupils in total. A multistage sampling procedure was used. In the first stage, eight wards were selected by simple balloting. In the second stage, fifteen schools were selected by balloting from the selected wards. In the third stage, eligible pupils were chosen from each school by simple random sampling.

Questionnaire Administration

A pre-validated questionnaire was administered to every participant to obtain demographic data (age and sex), parental education and main family income, water-contact behaviour, source of water supply, type of toilet facility and handwashing practice.

Collection of Urine samples and Parasitological Examination

Each pupil was given a sterile, labelled, wide-mouthed, screw-capped 20 ml container and instructed on correct collection. Terminal urine was collected between 10:00 a.m. and 2:00 p.m., the period of peak egg excretion

(Cheesbrough, 2005; Carvalho Cabral *et al*., 2019). Samples were kept at 4–6 °C in a cooler box and transported within five hours to the Laboratory of the Department of Microbiology, Federal University Dutsin-Ma. Five milliliters of each sample were centrifuged at 400 rpm for 4 minutes using a C2 Series Centurion Scientific Centrifuge and the deposit was examined under the 10x objective of a binocular light microscope. A sample was recorded as positive for *S. haematobium* when eggs with a characteristic terminal spine were seen (Cheesbrough, 2005). For quality control, 20% of the samples were selected at random and re-examined independently by a second parasitologist.

Bacteriological Examination

Urine samples were inoculated onto Nutrient agar, Mannitol Salt agar and MacConkey agar, and incubated at 37 °C for 24 hours. Isolates were identified by colony morphology, Gram staining and standard biochemical tests (including catalase, slide coagulase, oxidase, indole, methyl red, Voges–Proskauer, citrate utilisation, mannitol and lactose fermentation and triple sugar iron) as outlined by Cheesbrough (2005). Pupils were classified into four mutually exclusive groups: *S. haematobium* infection alone, bacteriuria alone, co-infection (eggs and bacteria) and no infection.

Data Analysis

Data were entered into Microsoft excel sheet and analysed using IBM SPSS version 22.0. Frequencies and percentages were computed. Chi-square tests were used to compare prevalence between LGAs and to assess associations between infection group and risk factors. Crude odds ratios (OR) at 95% confidence intervals (CI) were calculated by comparing pupils with any infection (*S. haematobium*, bacteriuria or both) against uninfected pupils. A *p*-value below 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Characteristics of the Participants

A total of 3,030 pupils aged 5–13 years were studied, of whom 2,408 (79.5%) were male. More than half (53.3%) were aged 11–13 years, and 61.1% had parents with no formal education. Farming (41.3%) and fishing (24.8%) were the leading sources of family income. Regarding exposure, 57.9% of pupils used river or stream water as their main water source, 58.5% practised open defecation, 53.0% reported frequent water contact and 65.4% reported not washing their hands or doing so only sometimes. Almajiri pupils made up 59.5% of the sample (Table 1).

Table 1: Socio-demographic, environmental and behavioural characteristics of the pupils

Variable (*n*= 3,030)	Category	*n*	%
Age group (years)	5–7	850	28.1
	8–10	564	18.6
	11–13	1,616	53.3
Sex	Male	2,408	79.5
	Female	622	20.5
Parental education	None	1,850	61.1
	Primary	650	21.5
	Secondary	380	12.5
	Tertiary	150	4.9
Main family income	Farming	1,250	41.3
	Fishing	750	24.8
	Trading	680	22.4
	Civil service	350	11.6
School type	Almajiri	1,804	59.5
	Primary (formal)	1,226	40.5
Water source	River/stream	1,755	57.9
	Improved (borehole/tap)	1,275	42.1
Toilet type	Open defaecation	1,774	58.5
	Improved (latrine/flush)	1,256	41.5
Water contact	Frequent	1,605	53.0
	Rare/never	1,425	47.0
Handwashing	No/sometimes	1,982	65.4
	Yes	1,048	34.6

Prevalence of S. haematobium Infection, Bacteriuria and Co-infection

Of the 3,030 pupils, 670 (22.1%) had *S. haematobium* infection alone, 484 (16.0%) had bacteriuria alone and 183 (6.0%) had both infections, while 1,693 (55.9%) were free of both (Table 2). Taken together, 853 pupils (28.2%) tested positive for *S. haematobium* and 667 (22.0%) had bacteriuria, and 1,337 (44.1%) had at least one infection.

Table 2: Infection status of the pupils

Infection status (*n*= 3,030)	*n*	%
S. haematobium alone	670	22.1
Bacteriuria alone	484	16.0
Co-infection	183	6.0
No infection	1,693	55.9
Any infection	1,337	44.1

Geographical Distribution

Kura had the highest prevalence of *S. haematobium* alone (26.3%), bacteriuria alone (18.8%) and co-infection (6.9%), followed by Dambatta (21.1%, 16.4% and 6.0%) and Wudil (18.9%, 12.7% and 5.1%). The differences between LGAs were significant for *S. haematobium* ($\chi^2 = 17.09$, $p < 0.001$) and bacteriuria ($\chi^2 = 14.42$, $p < 0.001$) but not for co-infection ($\chi^2 = 2.83$, $p = 0.243$). The proportion of pupils with any infection was 52.1% in Kura, 43.6% in Dambatta and 36.7% in Wudil (Table 3).

Table 3: Distribution of infections by LGAs

LGA	Examined	*S. haematobium* alone *n* (%)	Bacteriuria alone *n* (%)	Co-infection *n* (%)	Any infection *n* (%)
Kura	1,010	266 (26.3)	190 (18.8)	70 (6.9)	526 (52.1)
Dambatta	1,010	213 (21.1)	166 (16.4)	61 (6.0)	440 (43.6)
Wudil	1,010	191 (18.9)	128 (12.7)	52 (5.1)	371 (36.7)
Total	3,030	670 (22.1)	484 (16.0)	183 (6.0)	1,337 (44.1)
χ^2 (df = 2)		17.09	14.42	2.83	
p-value		<0.001	<0.001	0.243	

Risk Factors Associated with Infection

All five exposure variables differed significantly across the four infection groups ($p < 0.001$; Table 4). Use of river or stream water rose from 36.8% among uninfected pupils to 78.9% (bacteriuria alone), 86.4% (*S. haematobium* alone) and 93.3% (co-infection). Open defecation was reported by 44.1% of uninfected pupils and by 73.7–83.3% of infected pupils. Frequent water contact showed the steepest gradient, increasing from 22.1% in uninfected pupils to 84.2%, 95.5% and 100% in the three infected groups. Almajiri attendance (44.1% versus 73.7–83.3%) and inadequate handwashing (58.8% versus 66.7–84.2%) were also more common among infected pupils.

Pupils with any infection were more likely than uninfected pupils to be exposed to each risk factor (Table 5). The crude odds were highest for frequent water contact (OR = 41.0), followed by river or stream water use (OR = 9.5), Almajiri attendance (OR = 4.8), open defecation (OR = 4.2) and inadequate handwashing (OR = 2.0).

Table 4: Risk factors of urinary schistosomiasis and bacteriuria among school-aged children in Kano

Risk factor (unfavourable category)	No infection (*n* = 1,693)	Bacteriuria alone (*n* = 484)	*S. haematobium* alone (*n* = 670)	Co-infection (*n* = 183)	χ^2 (df = 3)	*p*-value
River/stream water source	623 (36.8)	382 (78.9)	579 (86.4)	171 (93.3)	715.6	<0.001
Open defecation	747 (44.1)	357 (73.7)	518 (77.3)	152 (83.3)	333.8	<0.001
Frequent water contact	374 (22.1)	408 (84.2)	640 (95.5)	183 (100.0)	1,488.3	<0.001
Almajiri school	747 (44.1)	357 (73.7)	548 (81.8)	152 (83.3)	387.5	<0.001
Handwashing: no/sometimes	995 (58.8)	408 (84.2)	457 (68.2)	122 (66.7)	111.6	<0.001

Table 5: Crude association between exposure and any infection

Risk factor (unfavourable category)	Any infection, exposed (%)	Any infection, unexposed (%)	Crude OR (95% CI)
River/stream water source	64.5	16.1	9.5 (7.9–11.3)
Open defecation	57.9	24.7	4.2 (3.6–4.9)
Frequent water contact	76.7	7.4	41.0 (32.6–51.5)
Almajiri school	58.6	22.8	4.8 (4.1–5.6)
Handwashing: no/sometimes	49.8	33.4	2.0 (1.7–2.3)

Discussion

This study provides community-based estimates of urinary schistosomiasis, bacteriuria and their co-infection in three LGAs of Kano State. Almost half of the 3,030 pupils (44.1%) had at least one infection: 28.2% excreted *S. haematobium* eggs, 22.0% had bacteriuria and 6.0% had both. The co-infection rate is far lower than the 53.7–60.0% reported among female subjects in Cross River State (Ubi *et al*., 2024) and the 53.6% reported among almajiri children in Safana, Katsina State (Alabi *et al*., 2023). Differences in the age and sex distribution of the infections among the population may be attributable to the sensitivity of diagnostic methods and in how bacteriuria was defined and they limit direct comparison between studies. The present figures nonetheless show that a sizeable minority of infected children carry a second, bacterial infection that most schistosomiasis programmes do not look for (Kone *et al*., 2022).

Prevalence differed significantly between LGAs, with Kura highest for both *S. haematobium* (26.3%) and bacteriuria (18.8%). Kura is one of the most extensively irrigated LGAs in the State, and irrigation and water-resource development can create and sustain snail habitats (Sule *et al*., 2025). Such local variation is typical of northern Nigeria, where infection ranges from very high in some communities to negligible where intermediate host snails are absent (Duwa *et al*., 2009; Ajakaye *et al*., 2022; Ishiekwene *et al*., 2024; Dikwa *et al*., 2025). Co-infection did not differ significantly between LGAs ($p = 0.243$), which suggests that the exposures that bring the two infections together are shared across the study area rather than specific to a location, an interpretation consistent with the similar determinants reported in Ondo State (Kone *et al*., 2022). The number of co-infected pupils per LGA was small; however, so modest differences may have gone undetected.

Frequent water contact showed the clearest gradient, rising from 22.1% in uninfected pupils to 100% in co-infected pupils. This agrees with studies in Katsina and Sokoto States in which irrigation, fishing, farming and swimming were the main activities linked to infection (Dikwa *et al*., 2025) and with the strong role of water contact reported in Osun State (Olusi *et al*., 2024). Reliance on river or stream water and open defecation were also strongly associated with infection, in line with reports from Sokoto, Makurdi and Jigawa State (Balogun *et al*., 2022; Jande *et al*., 2025) and from Ogun State, where sanitation practices influenced risk (Uthman *et al*., 2024). Not every study finds sanitation to be dominant. In Cross River State, knowledge of how schistosomiasis is transmitted was a stronger predictor of infection than sanitation infrastructure (Imalele *et al*., 2024), and in pastoral communities around Ramsar wetlands infection varied despite similar sanitation (Ajakaye *et al*., 2022). Awareness and hygiene practice have likewise been linked to lower risk of infection in Ghana (Owusu *et al*., 2025). The odds ratios in this study, particularly for water contact (OR = 41.0), should be read with caution: they are crude, they come from a cross-sectional survey, and exposure was self-reported and may partly overlap with the way infection groups were defined.

Attendance at Almajiri schools was strongly associated with infection (OR = 4.8), supporting earlier evidence that these children are especially vulnerable (Alabi *et al*., 2023; Auta *et al*., 2024). Almajiri pupils often live and bathe outside the home with limited access to safe water, sanitation and health education. Studies of out-of-school children in Kebbi State suggest that the disparity may be driven by limited access to treatment and health education rather than by school type itself (Bazata *et al*., 2025), so school type is better regarded as a marker of broader social and environmental disadvantage.

The frequent co-occurrence of *S. haematobium* and bacteriuria is biologically plausible. Egg deposition injures the bladder epithelium, and parasite-driven immune modulation may weaken local antibacterial defences, which together favour bacterial invasion (Barsoum, 2013; Ossai *et al*., 2014; Mbanefo *et al*., 2020; Perera *et al*., 2024). Because the design was cross-sectional, this study cannot show which infection came first. Aligning schistosomiasis control with surveillance for bacterial infection and antimicrobial resistance has been proposed as part of a One Health approach (O'Ferrall *et al*., 2024).

This study has limitations. Infection was assessed from a single urine sample, and microscopy is less sensitive than molecular methods, especially in light infections (Weerakoon *et al*., 2015), so true prevalence is probably higher. Exposure data were self-reported, school-level clustering was not modelled, and the odds ratios were unadjusted. Males made up about four in five of the pupils, which limits generalisation to girls. Pupils who had recently taken antibiotics or received Praziquantel were excluded, which may also have lowered the estimates.

CONCLUSION

Urinary schistosomiasis and bacteriuria are common among school-aged children in Kura, Dambatta and Wudil LGAs of Kano State, with Kura bearing the highest burden. Contact with open water, reliance on river or stream water, open defecation, inadequate handwashing and Almajiri school attendance were all strongly associated with infection, and co-infection was spread similarly across the three LGAs. Control should therefore combine Praziquantel treatment with water, sanitation and hygiene improvements.

RECOMMENDATIONS

1. Treat pupils in Kura, Dambatta and Wudil with Praziquantel through school-based mass drug administration, with Kura first because it had the highest burden.

2. Culturally appropriate health education in formal and Almajiri schools, and the inclusion of urine culture and antibiotic susceptibility testing in schistosomiasis surveillance. Priority should be given to Almajiri schools and to Kura Local Government Area.
3. Provide safe water points (boreholes or taps) in the communities that rely on rivers and streams, and discourage children from bathing and playing in open water bodies.
4. Build latrines and run community-led sanitation campaigns to cut open defecation.
5. Give priority to Almajiri (Tsangaya) schools, with provision of water, sanitation, handwashing facilities and regular treatment.
6. Run health education in formal and Almajiri schools on how schistosomiasis is transmitted and why handwashing matters.
7. Add urine culture and susceptibility testing to schistosomiasis surveillance, so co-infection is detected and treated.
8. Future studies should use more sensitive diagnostics (PCR or antigen tests), examine repeat urine samples, adjust for school clustering with multivariable models, and include more girls.

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