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Research paper

Ecological Assessment of Freshwater Snails and Schistosomiasis Transmission in Doma Local Government Area, Nasarawa State, Nigeria

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ABSTRACT

Schistosomiasis is a parasitic disease caused by trematode worms of the genus *Schistosoma*. This study assessed freshwater snails' occurrence and schistosomiasis transmission in Doma LGA, Nasarawa State, Nigeria, from November 2024 to January 2025. Snails and water physicochemical parameters were sampled weekly across nine sites using scoop nets and manual collection. Ethical approval was obtained, and stool and urine samples were collected from 361 consenting participants and analyzed using sedimentation (urine) and direct smear (stool) techniques. Physicochemical parameters varied, with some sites showing slightly acidic conditions (pH 5.5–6.5) that may limit snail survival. The overall schistosomiasis prevalence was 4.43%, all due to *S. haematobium* infection. The highest infection rate (11.76%) occurred in Yelwa Doma 1 with significant variations among sites (χ^2 = 39.472, df = 8, p < 0.001). Prevalence was slightly higher in males (4.49%) than females (4.31%) though not statistically significant (P > 0.05). Infection correlated significantly with residency of 1–5 years, poor knowledge of the disease, and frequent water contact activities such as bathing and swimming. Children aged 1 – 10 years old had the highest infection intensity, while microhaematuria was most common among those aged 11 – 20 years. These findings highlight the need for sustained integrated control strategies including health education, improved access to clean and safe water, and targeted mass drug administration.

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Introduction

Schistosomiasis, also known as bilharziasis, is a parasitic disease of major medical and public health significance caused by trematode worms of the genus *Schistosoma*. It ranks second only to malaria among parasitic diseases in terms of global impact, causing considerable morbidity and socio-economic loss (James et al., 2018). The infection is transmitted through contact with freshwater contaminated by larval forms of the parasite, which penetrate human skin during activities such as farming, bathing, fishing, and washing (Reitzug et al., 2023). Although its mortality rate is comparatively low, schistosomiasis leads to chronic and debilitating illness, impairing growth, cognitive development, and productivity, particularly in impoverished rural areas where sanitation is poor and water contact is frequent (McManus et al., 2020). The disease remains a neglected

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tropical disease (NTD) of major concern across Africa, Asia, and the Americas, with millions of people suffering from severe complications each year.

Trematodes, including schistosomes, dominate the class of parasitic flatworms, comprising over 18,000 nominal species that exhibit remarkable diversity and complex multi-host life cycles (Duan et al., 2021). These parasites typically utilize molluscs, especially freshwater snails, as their first intermediate hosts, while vertebrates such as fish, amphibians, reptiles, birds, and mammals serve as definitive hosts (Pitaksakulrat et al., 2022). In the genus *Schistosoma*, the asexual stages occur within snails (intermediate hosts), while the sexual stages develop in humans (definitive hosts) (Buddenborg et al., 2023). Human infection occurs when free-swimming cercariae released from infected snails penetrate the skin upon water contact. Inside the host, the larvae develop into adult worms that reside in venous plexuses of the intestine or urinary bladder, depending on the species, and release eggs that are excreted in feces or urine to continue the life cycle (Ekloh et al., 2024). Some eggs become trapped in host tissues, leading to granulomatous inflammation and tissue damage that cause the chronic morbidity characteristic of schistosomiasis (Zhong et al., 2022). Severe infections may result in hepatic fibrosis, renal failure, or bladder carcinoma if untreated (Santos et al., 2021).

Globally, the World Health Organization (1993) recognizes nineteen *Schistosoma* species, five of which are of major pathological significance to humans: *S. haematobium, S. mansoni, S. japonicum, S. mekongi*, and *S. intercalatum*. Together, these species infect over 200 million people annually, with approximately 600 million at risk across 74 countries. More than 95% of these infections occur in Africa, where *S. haematobium* and *S. mansoni* predominate (Mewamba et al., 2021). Despite large-scale mass drug administration (MDA) campaigns using praziquantel, schistosomiasis persists as a major public health problem, particularly in areas with inadequate water supply, sanitation, and snail control programs (King et al., 2005). Water-resource development projects such as irrigation schemes often exacerbate transmission by creating favorable snail habitats (Guo et al., 2021). Control strategies are further constrained by reinfection, limited community compliance, and insufficient ecological surveillance of snail populations. Thus, while global and national control programs have achieved partial success in reducing disease burden, the sustainability of these interventions remains limited by ecological and socio-behavioral factors influencing transmission (Wilson et al., 2020).

In Nigeria, schistosomiasis is widespread and continues to pose a major public health challenge. The disease affects millions of people, particularly those living in rural and peri-urban areas dependent on natural freshwater sources (Ombugadu et al., 2022). Doma Local Government Area (LGA) in Nasarawa State provides a representative example of such endemic settings. The area is characterized by abundant streams, rivers, and irrigation channels that support agricultural and domestic activities, all of which promote frequent human–water contact. These aquatic environments potentially harbor snail species belonging to the family Planorbidae, known intermediate hosts of *Schistosoma* spp. However, there is a paucity of information on the diversity and distribution of freshwater snails in Doma LGA, as well as on the physicochemical parameters influencing their presence and infectivity. The lack of ecological data on snail habitats and cercarial shedding patterns limits understanding of local transmission dynamics and hinders the design of targeted control strategies in the region.

The present study was designed to assess the ecology of freshwater snails and the transmission dynamics of *Schistosoma* infection in Doma Local Government Area, Nasarawa State, in relation to the assessment of snail's abundance in association to Physicochemical parameters of water bodies in the study area, the prevalence of schistosomiasis in the study area, and in relation to the knowledge of the respondents, evaluation of the infectivity rate in relation to attitude and practice of respondents, and determination of the mean intensity of infection and the mean haematuria rate of *Schistosoma haematobium* among the respondents, respectively. Collectively, these objectives were formulated to add to already existing baseline ecological and epidemiological data that would enhance understanding of schistosomiasis transmission patterns in Doma LGA. The outcomes are expected to inform evidence-based control strategies, guide public health interventions, and support the development of integrated management programmes tailored to local environmental conditions.

Materials and Methods

Study Area

The study was conducted in Doma Local Government Area of Nasarawa State, located between latitudes 8^0 5'N and 8^0 24'N and longitudes 6^0 00E and 6^0 30'E (Figure 1). The area lies about 22 kilometres north of Lafia, and it is characterised by a tropical climate with a mean annual rainfall of 1,200 – 1,800mm. The mean annual temperature of Doma Local Government is approximately 27 ^{0}C to 30 ^{0}C with general year round daily temperature typically varying between 18 ^{0}C (64 ^{0}F) and 36 ^{0}C (96 ^{0}F). The well-established dendritic drainage system in Doma Local Government Area (LGA) is made up of seasonal and perennial rivers and streams that sustain domestic and agricultural activities while offering habitats that are conducive to freshwater snails. The

Doma Dam River, the primary watercourse, runs from northeast to southwest and is a vital source for domestic use, agriculture, and livestock. Because of increased surface runoff, the stream density is highest near Doma town and Yelwa Doma 1, and it falls toward the eastern boundary as a result of changing topography.

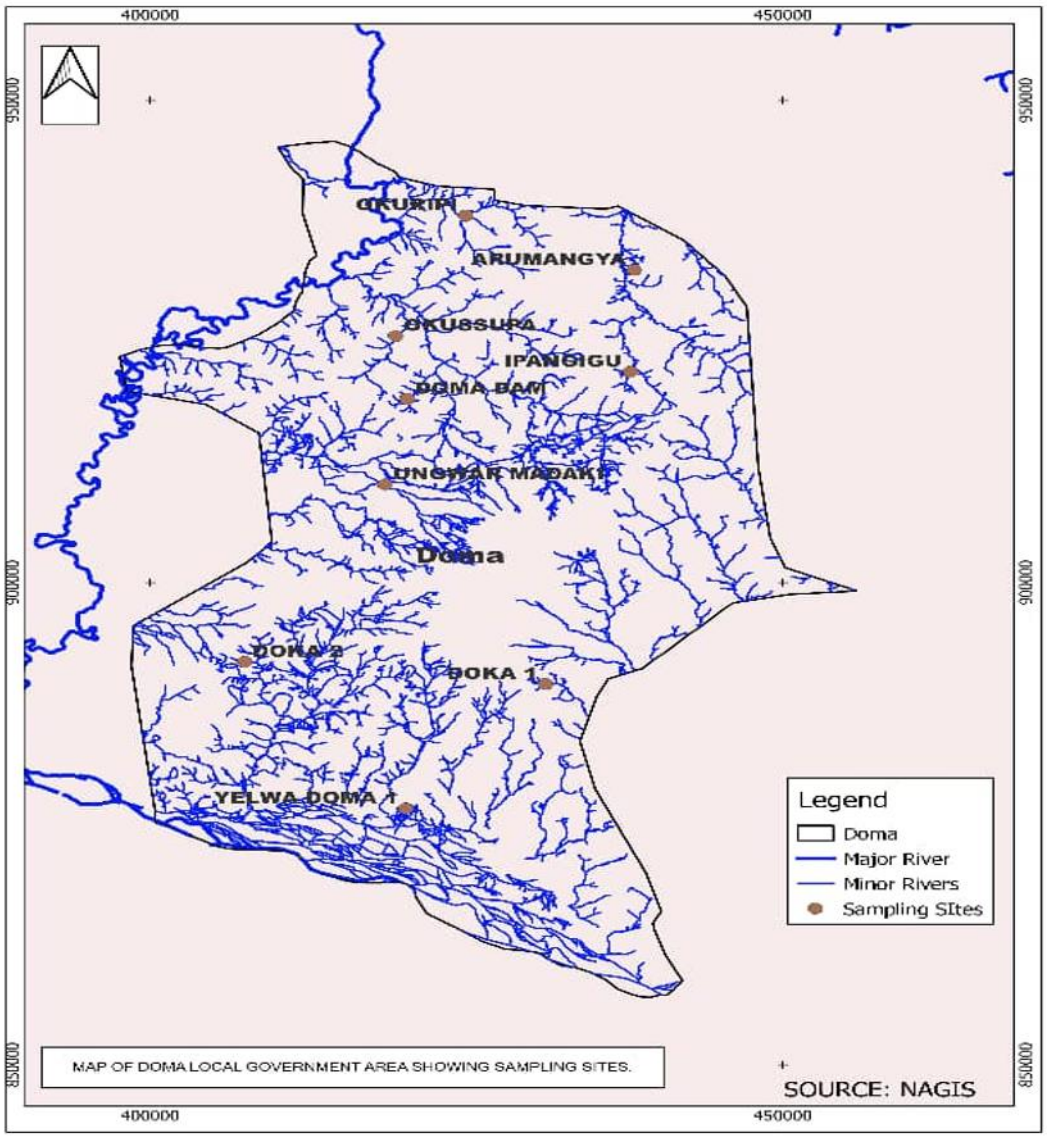


Figure 1: Map of Sites Sampled in Doma Local Government Area of Nasarawa State, Nigeria
(Source: Nasarawa Geographic Information Service, 2024)

Survey of Sampling Sites

Human activities in and around these bodies of water were noted. Nine locations were randomly selected to collect vector snails. Snails were collected in each site with at least 200 meters apart (Hailegebriel et al., 2022). The frequency of human-water contact during water fetching, clothing washing, bathing, swimming, fish processing, and other household tasks was taken into consideration while choosing the specific sample collection locations (Hailegebriel et al., 2022). A Global Positioning System receiver (UTM Geo Map) was used to gather each site's geographic coordinates.

Ethical Clearance

Ethical approval with reference number 12/02/2024, was obtained from the Nasarawa State Ministry of Health for the purpose of the survey. Additionally, the parents or guardians of the adults or children gave their consents. Three hundred and sixty-one (361) participants, including adults and children of all ages, gave their agreement and were enrolled in the study, as against 399 participants initially targeted for the study.

Snail Vector Collection

Snail collection was conducted weekly between 07:00 and 10:00 hours from November 2024 to January 2025 at nine sites. No freshwater snails were collected from the nine distinct locations. Additionally, a scoop net with wire mesh on an iron frame and mounted on a 1.5-meter-long iron handle was used for the snail's collection. Additionally, safety gloves and forceps were used for hand picking (Okete et al., 2020). At each sampling

location, no sample was taken from the area of approximately 5 m2 of river and stream water as well as in areas of 55 m along the shorelines of certain rivers and streams (Hailegebriel et al., 2022).

Identification of Snails

Morphological features according to Okete et al. (2020) were used to identify the snails. However, no snails were found in all the study locations.

Parasitological Assessment

Determination of sample size

Sample size was determined using the formula described by Yamane and Davidson (1961), as follows:

n=N/1+N (e2)

Where:

n = is the sample size,

N = is the population size = 139,607

e = is the margin of error = 0.05

Imputing the values

n = N/1+ 139607 (0.052)

n = 399

Non Bias Analysis

Target sample 399, achieved 361 (90.5% response). Observed prevalence 4.43% (95%cl: 2.32% - 6.54%). Sensitivity analysis assuming non-respondents had 0% to two times the observed prevalence yields an overall prevalence range of 4.01% to 4.76%. Demographic data were not available for non-respondents, limiting assessment of non-despondence bias.

Collection and Laboratory Examination of Urine and Stool Samples

After completing a questionnaire, urine and stool samples were collected from consenting participants between November, 2024 and January, 2025. A clean catch terminal urine sample (10–15 ml) was taken from each subject and placed in a screw-capped, dry, sterile, and clean wide mouth urine container. The identity code of the study participants was appropriately affixed to the containers. Between 10:00 am and 2:00 pm, the sample was collected (Cheesebrough, 2013). The labelled containers with stool and urine samples were returned the following morning and placed in an ice chest with ice packs surrounding them. The samples were then taken to the laboratory of Federal University of Lafia for examination. After a physical examination and a urine biochemistry test, the stool and urine samples were analysed three to eight hours after they were collected. Samples of urine and stool were recorded according to their nature (colour and appearance) and consistency. Additionally, every urine sample was recorded and checked for any obvious signs of turbidity or haematuria. Urinalysis strips were used to identify and document haematuria.

After dipping each commercially made reagent strip (Kroma 10E Test) into a urine sample, the colours that formed were compared to standard colours on the side of the reagent strip container. The stool and urine samples were processed using direct smear and centrifugation methods, respectively. In order to grade the severity of the infection, schistosome ova were counted and categorised using the approach that takes into account the quantity of eggs in 10 millilitres of urine (Mafiana et al., 2003). Therefore, minor infections were defined as 1–9 eggs per millilitre, moderate infections as 10-49 eggs per millilitre, and high infections as >50 eggs per millilitre. An intestinal schistosomiasis infection was considered light if there were 1–99 eggs per gramme of stool, moderate if there were 100–399 eggs per gramme of stool, and heavy if there were 400 or more eggs per gramme of stool (Wiegand et al., 2021).

Water Sample Collection and Processing

Water samples were taken from nine geographic locations along the Doma River's course and channels and examined for three weeks according to the methods outlined by Geypens (2012). Using a handheld portable water quality tester (Combo HANNA), the following parameters were measured: temperature, pH, electrical

conductivity (EC), and total dissolved solids (TDS). A standard Bioevopeak digital DO and BOD portable meter, model numbers DO-P310F and BOD-573 were used to measure the dissolved oxygen (DO) and biochemical oxygen demand (BOD), respectively.

Structured Questionnaires Administration

Consenting respondents were administered a well-structured questionnaire. The partcipant's were asked for biographical information, including their age, occupation, water contact activities, living conditions (such as the type of water supply and the state of the toilet system), health status (such as whether blood was present in their urine or stool), etc.

Data Analysis

All data were analyzed using R version 3.6.1. Descriptive statistics summarized demographic variables and infection prevalence. Pearson's Chi-square test assessed associations between infection rates and demographic or behavioral variables. Statistical significance was set at $p < 0.05$.

Arithmetic Mean intensity of parasite (AMI)

$$\bar{x} = \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right) = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

Mean hematuria intensity

The unusual occurrence of blood in the urine is known as haematuria. Counting the number of red blood cells (RBCs) per high-power field (HPF) in a urine sample under a microscope is the standard method for determining the degree of microhematuria (Kincaid-Smith, 2005)

$$\text{Microheamaturia intensity} = \frac{\text{Number of samples present with blood} \times 100\%}{\text{Number of infected samples}}$$

Results

Snails Occurrence and Physico-chemical Parameters of the Water Bodies Sampled

No snail was found in all the water bodies surveyed. Although phyisco-chemical conditions recorded would favour snail population in the study area. Doka 1 recorded the lowest temperature (26°C), while Doka 2 and Doma Dam recorded maximum temperature (28°C) (Table 1). Yelwa Doma 1 reported the highest pH at 6.5, while Doma Dam had the lowest pH at 5.5.Arumangya recorded the lowest DO at 3.6 mg/L, and Okpuripu had the highest DO at 5.2 mg/L. The biochemical oxygen demand (BOD) readings varied from 1.0 mg/L to 3.4 mg/L.

Arumangya had the lowest BOD at 1.0 mg/L, whereas Okpuripu had the highest BOD at 3.4 mg/L. Ipangigu recorded the lowest alkalinity at 58 mg/L, while both Doma Dam and Yelwa Doma 1 had the highest alkalinity at 80 mg/L. Doka 1 had the highest turbidity (98 cm), whereas Doka 2 and Ungwar Madaki had the lowest turbidity (68 cm).

Table 1: Abundance of Snails and Physicochemical Parameters of the Water Bodies Sampled

Location	Occurrence of snails	Water Parameters						
		Temp(°C)	PH	DO (MG/L)	BOD (MG/L)	Total Alkalinity (MG/L)	Turbidity (CM)	Electrical Conductivity (µS/CM)
Yelwa Doma 1	0	27	6.5	4	1.8	78	80	40.1
Doka 1	0	26	6	4.6	1.8	68	98	33.6
Doka 2	0	28	6	3.8	1.4	66	78	45
Ungwar Madaki	0	27	6	4.4	2.4	66	70	48
Doma Dam	0	28	5.5	4.6	1.8	80	80	42
Arumangya	0	27	6	3.6	1	73	75	40
Okpuripu	0	27	6	5.2	3.4	65	83	43

Okussupa	0		27	6	5	3.2	60	78	40
Ipangigu	0		27	6	4.6	2.8	58	78	40

Prevalence of *Schistosoma* Species Infection in Doma LGA, Nasarawa State

Out of the 361 participants examined, 16 (4.43%) were positive for *Schistosoma haematobium* infection, while no *S. mansoni* infection was detected (Table 2). The highest infection rate was recorded in Yelwa Doma 1 (11.76%), followed by Arumangya (10.87%) and Doka 1 (7.02%). No infection was observed in Doma Dam, Okussupa, and Ungwar Madaki. The difference in prevalence among locations was statistically significant (χ^2 = 39.472, df = 8, p < 0.001).

Table 2 Prevalence of *Schistosoma* Species Infection in Doma LGA, Nasarawa State

Location	No. Examined	No. Infected with *S. heamatobium*	No. Infected with *S. mansoni*	Prevalence
Arumangya	46	**5**	0	10.87
Doka 1	57	4	0	7.02
Doka 2	50	3	0	6
Doma Dam	31	0	0	0
Ipugigu	34	1	0	2.94
Okpuripu	75	1	0	1.33
Okussupa	23	0	0	0
Ungwar Madaki	28	0	0	0
Yelwa Doma 1	17	2	0	11.76
Total	**361**	**16**	0	**4.43**

χ^2 = 39.472, df = 8, p<0.001

Prevalence of Schistosomiasis with Respect to Demographic Data

Schistosomiasis was most common in subjects (participants) aged 1–10 years (18.75%), followed by those aged 11–20 years (7.21%), 21–30 years (4.76%), and those aged 41–50 years (1.22%). As a result, the prevalence of Schistosomiasis varied significantly by age group (χ^2 =37, df =5, p<0.05) (Table 3). Males had a higher prevalence of schistosomiasis (4.49%) compared to females (4.31%). On the other hand, there was no significant difference between males and females (χ^2 = 0.003, df = 1, p = 0.9516).

Table 3: Prevalence of Schistosomiasis with Respect to Demographic Data

Parameters	Number Examined	No. Infected	Infection Rate (%)	χ^2	Df	P Value
Age (yrs)						
1- 10	16	3	18.7	37.408	5	P<0.001
11- 20	111	8	7.21			
21-30	42	2	4.76			
31-40	65	1	1.54			
41-50	82	1	1.22			
≥51	45	1	2.22			
Total	**361**	**16**	4.43			
Sex						
Male	245	11	4.49	0.0036818	1	0.9516
Female	116	5	4.31			
Total	**361**	**16**	4.43			
Marital Status						

Single	203	12	5.91	1.3536	1	0.2446
Married	158	4	2.53			
Total	**361**	**16**	4.43			
Occupation						
Civil Servants	26	1	4.35	13.241	5	0.02122
Farming	99	2	2.02			
Trading	68	2	3.13			
Fishing	32	2	7.07			
Pupil/Student	99	7	9.38			
Others	37	2	5.41			
Total	**361**	**16**	4.43			
Educational Level						
Non- formal	159	9	5.77	1.5488	2	0.461
Semi – formal	116	6	5.22			
Formal	43	1	2.32			
Total	**361**	**16**	4.43			

Prevalence of Schistosomiasis in Relation to Residency Period

Schistosoma infection was most common among participants who had lived in the area for 1–5 years (25.00%), while there were no cases among those who had lived there for 26–30 years (0.00%). According to the length of stay, there is a statistically significant variation in the prevalence of schistosomiasis (χ^2 = 65, df = 6, P < 0.0001) (Table.4.4).

Table 4: Prevalence of Schistosomiasis in Relation to Residency Period

Residency Period (Years)	No. of Respondents	No. Infected	Infectivity Rate (%)
1-5	4	1	25.00
6-10	21	4	19.05
11-15	76	4	5.26
16-20	41	1	2.44
21-25	37	2	5.41
26-30	3	0	0.00
31>	179	4	2.23
Total	**361**	**16**	4.43

χ^2= 65.048, df = 6, p<0.001

Prevalence of Schistosomiasis in Relation to the Knowledge of Respondents about the Disease

More responders (5.23%) were infected than those who knew about the condition beforehand (4.10%). As a result, the infectivity rate of schistosomiasis did not differ significantly (χ^2 = 4.8703, df = 2, P = 0.08759) between individuals who had previously learnt about the disease and those who did not. Those who learnt about schistosomiasis via religious leaders and public education programs were not infected (0.00%), but those who learnt about it from schools had the highest infectivity rate (6.25%) (Table5).

The prevalence of infection was higher among those who had never had treatment for the illness (81.25%) than among those who had treatment in the past 12 months (12.5%). The prevalence of Schistosomiasis did not differ significantly between respondents who had previously received therapy and those who had never received it (χ^2 = 103.91, df = 2, P > 0.01). Participants who recognised that painful urination (dysuria) and blood

in the urine (haematuria) were signs of schistosomiasis had zero infectivity rates (0.00%), but those who were unsure of the symptoms had the greatest infectivity rate (56.25%).

The prevalence of schistosomiasis was therefore significantly different between individuals who were certain of the symptoms and those who were not ($\chi^2 = 129.69$, df = 5, P > 0.01). Schistosomiasis was the most common infection among those who did not employ precautionary measures (33.3%), while the infectivity rate was lower among those who did (1.21%). As a result, the infectivity rate of Schistosomiasis differed significantly ($\chi^2 = 30.171$, df = 2, P = 2.102) between respondents who used precautionary measures and those who did not.

Table 5 Prevalence of Schistosomiasis in Relation to the Knowledge of Respondents about the Disease

Parameter	Variables	No. of Respondents	No. Infected	Infection Rate	χ^2	df	P-Value
Prior knowledge	Yes	195	8	4.1	4.8703	2	0.08759
	No	153	8	5.23			
	No response	13	0	0			
Source of Information	Posters	14	0	0	17.098	5	0.00432
	School	16	1	6.25			
	Radio/TV	122	7	5.74			
	Religious Leaders	4	0	0			
	Public enlightenment	30	0	0			
	Others	175	8	4.57			
Treatment in past 12 months	Yes	90	2	12.5	103.91	2	p<0.001
	No	225	13	81.25			
	Uncertain	46	1	6.25			
Knowledge of Symptoms of Infection	Blood in the urine	24	0	0	129.69	5	p<0.001
	Fever	22	2	12.5			
	Painful urination	9	0	0			
	Headache	90	3	18.75			
	Stomach ache	23	2	12.5			
	Uncertain	193	9	56.25			
Heard of Snail- human Infections	Yes	74	2	2.7	1.1002	2	0.5765
	No	232	3	1.29			
	Uncertain	55	2	3.64			
Use of Protective Measures	Yes	331	4	1.21	30.171	2	2.102
	No	12	4	33.3			
	Uncertain	18	3	16.7			

Infection Rate of Schistosomiasis in Relation to Attitude and Practice of Respondents

Table 6 shows that respondents who utilize water from rivers were the most infected (6.40%) by *Schistosoma* species followed by those who use streams (5.06%). Whereas users of wells and other water sources were not infected. Therefore, the difference in the infection rate of *Schistosoma* infection across water sources utilized by the subjects varied significantly ($\chi 2$ = 12.98, df =4, P=0.01168). Subjects whose water contact activity was swimming were predominantly infected (14.29%), followed by those for bathing (6.45%) then farming (4.7%) while those who had contact with water while cooking were not affected (0%).Thus, there was a significant difference in Schistosomiasis infectivity in relation to water contact activities ($\chi 2$ = 24.642, df =5, P<0.001).

A high number of subjects who utilize water directly from source were infected (8.43%) than those that don't (2.88%). But, there was no significant difference ($\chi 2$= 2.7, df =1, P=0.09) in Schistosomiasis infection rate between subjects who use water directly from source and those what don't.

Table 6: Infection Rate of Schistosomiasis in Relation to Attitude and Practice of Respondents

Parameter	Variables	No. of Respondents	No. Infected	Infection Rate	χ^2	df	P-Value
Water Source	Borehole	53	1	1.89	12.918	4	0.01168
	River	172	11	6.40			
	Stream	79	4	5.06			
	Well Water	26	0	0.00			
	Others	31	0	0.00			
Water Contact activities	Washing	55	2	3.64	24.642	5	p<0.001
	Cooking	7	0	0.00			
	Bathing	62	4	6.45			
	Drinking	60	1	1.67			
	Farming	170	8	4.71			
	Swimming	7	1	14.29			
Water Usage Directly from Source	Yes	83	7	8.43	2.7235	1	0.09888
	No	278	8	2.88			
Toilet System Utilized	Gutter	29	3	10.34	51.807	5	p<0.001
	Water cistern	4	0	0.00			
	Pit Latrine	57	3	5.26			
	River/Stream	129	4	3.10			
	Bush	4	1	25.00			
	All of the Above	137	5	3.65			
Hand Washing with Soap	1 time/day	173	7	43.75	52.344	4	p<0.001
	2 times/day	62	3	18.75			
	3 times/day	95	4	25.00			
	4> times/day	15	0	0.00			
	None response/Nil	16	2	12.5			

Arithmetic Mean Intensity of Parasites and Mean Haematuria Intensity of *Schistosoma haematobium*

The highest mean intensity of *Schistosoma haematobium* infection and the highest mean occurrence of microhaematuria were recorded in the 1–10 and 11–20 year age groups, respectively. Conversely, individuals in the 31–40, 41–50, and ≥51 year age groups, who exhibited only light infections, did not present hematuria (Figure 2)

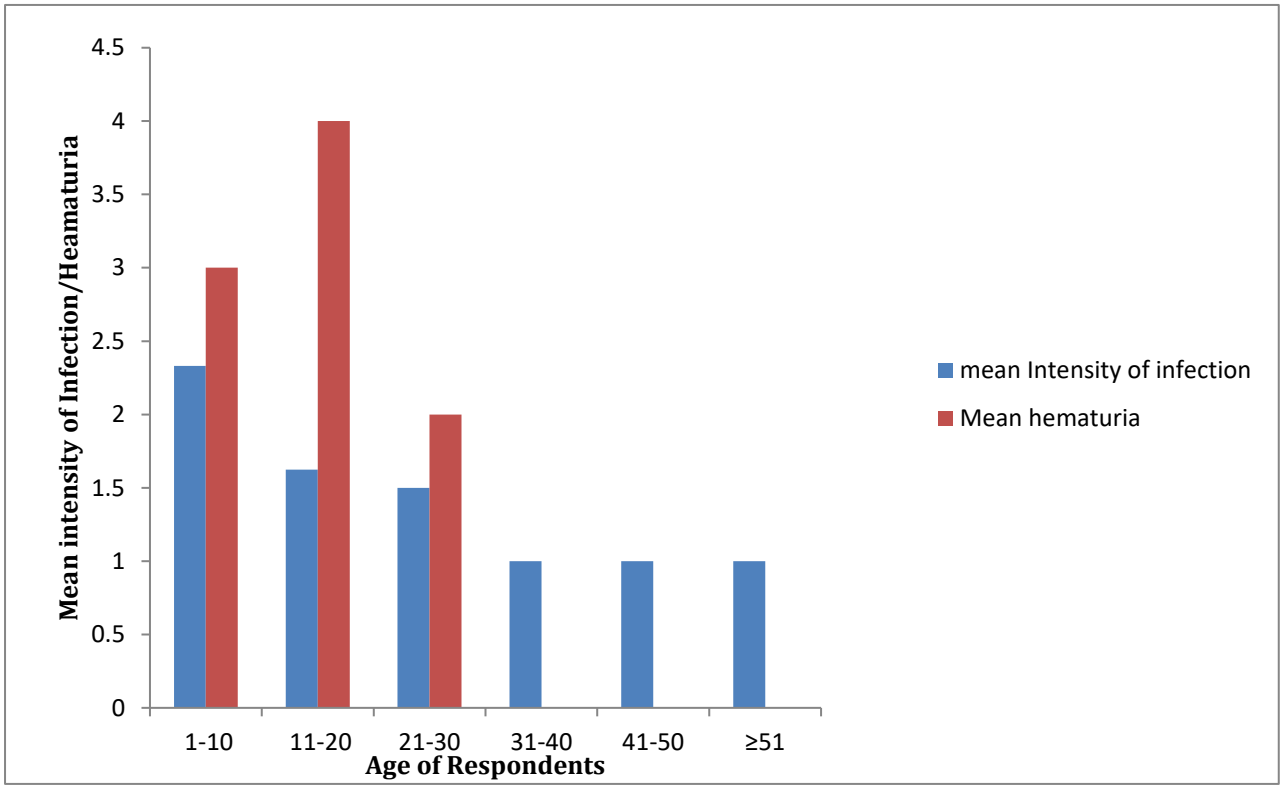


Figure 2: Arithmetic Mean Intensity of Infection and Mean Haematuria Intensity of *Schistosoma haematobium*

Discussion

Environmental and Physicochemical Influence

The absence of freshwater snails across all sampling sites in Doma Local Government Area (LGA) may be attributed to the combined influence of key environmental and physicochemical factors such as pH, dissolved oxygen (DO), alkalinity, and conductivity. These parameters are known to shape the survivability, distribution, and reproductive performance of aquatic snails, especially those serving as intermediate hosts for *Schistosoma* species (Chidimma et al., 2025). Although the recorded physicochemical parameters during this study largely fell within the general tolerance range for freshwater organisms, the specific interactions among them may have created conditions unsuitable for snail habitation.

pH, for instance, plays a crucial role in shell formation and metabolic processes. Most planorbid and bulinid snails thrive in slightly alkaline environments, typically ranging from pH 7.0–8.5 (WHO, 2023). However, local fluctuations in pH caused by decaying organic matter and agricultural runoff may have periodically reduced habitat suitability, limiting the establishment of breeding colonies. Closely linked to pH is alkalinity, which reflects the buffering capacity of the water body. High alkalinity, often associated with excessive bicarbonate ions, may influence calcium carbonate solubility, thereby affecting shell development and egg viability (Ninokawa et al., 2024). The correlation between alkalinity and pH observed in this study suggests that the aquatic environment may have experienced temporal instability, impairing snail colonization despite apparently favourable mean values.

Dissolved oxygen levels, another critical determinant, influence both the metabolic rate of snails and the microbial composition of the water. Although moderate DO levels were recorded, short-term depletions due to organic load or eutrophication can lead to physiological stress and reduced reproduction (Schernewski et al., 2024). Similarly, elevated electrical conductivity, indicative of high ion concentration or pollution from agricultural inputs, can disrupt osmotic balance in snails and alter the microhabitat required for juvenile

survival (Wisch, 2023). Therefore, the combined influence of marginal pH-alkalinity balance, suboptimal DO variability, and elevated conductivity likely contributed to the non-occurrence of snails, even in the presence of apparently adequate physicochemical conditions. These findings reaffirm the ecological sensitivity of freshwater snails and align with WHO's (2023) assertion that minor deviations from optimal ranges can substantially reduce snail abundance in endemic regions.

Local Ecological Suitability and Snail Distribution

Beyond water chemistry, ecological and habitat characteristics strongly determine snail occurrence. The absence of snails in the sampled sites suggests poor habitat quality arising from interacting environmental stressors such as periodic desiccation, sediment disturbance, and anthropogenic pollution. Seasonal water level fluctuations during the dry months of November to January, when the survey was conducted, may have caused excessive exposure of littoral zones, eliminating the shallow, vegetated microhabitats favoured by Bulinus and *Biomphalaria* species. Similar findings have been documented by Etuk et al. (2023) in southwestern Nigeria, where snail populations drastically declined during dry-season sampling despite optimal water chemistry.

The predominance of ephemeral streams and low-flow sections in Doma further limits the establishment of permanent snail colonies. Snails generally prefer stable, slow-moving, and vegetation-rich habitats (Boni, 2022). The sampled water bodies were, however, characterized by periodic scouring and siltation caused by agricultural activities, cattle trampling, and community washing points. These disturbances alter the benthic substrate and destroy aquatic vegetation, reducing the availability of attachment and feeding surfaces. In comparable West African settings, such as Ghana and Côte d'Ivoire, the absence or scarcity of snail hosts during dry months has been linked to habitat degradation and intermittent flow patterns (WHO, 2023). Therefore, while physicochemical conditions were not out rightly hostile, the cumulative ecological stress likely rendered the habitats unsuitable for snail establishment and persistence.

***Schistosoma* Infection Pattern**

Despite the absence of snail hosts, parasitological screening revealed a low overall prevalence (4.43%) of urinary schistosomiasis, with *Schistosoma haematobium* as the only detected species. This finding reflects the epidemiological dominance of Bulinus-transmitted schistosomiasis in northern and central Nigeria (WHO, 2023). The absence of intestinal schistosomiasis indicates that *Biomphalaria pfeifferi*, the intermediate host of *S. mansoni*, was either absent or present below detectable levels in local water bodies. The spatial concentration of infections in Yelwa Doma 1 and Arumangya supports the possibility of microfocal transmission, sustained by residual snail populations in unsampled or temporary habitats.

Spatial variability in infection suggests that transmission is localized and likely influenced by human-water contact intensity rather than widespread environmental suitability. Similar focal infection patterns have been reported in Bauchi and Niger States, where *S. haematobium* prevalence persisted around specific community water sources, even after snail absence during dry-season surveys (Umoh et al., 2020). This may result from human mobility and the survival of infected snails in isolated microhabitats that were not sampled. Hence, although the present study recorded no snails, the low but consistent detection of urinary schistosomiasis confirms that the local environment retains transmission potential, especially during wetter months when temporary pools re-emerge.

Demographic and Behavioural Determinants

The observed demographic trends in infection prevalence highlight the interplay between exposure behaviour, biological susceptibility, and social factors. Children aged 1–10 years exhibited the highest infection prevalence, consistent with frequent recreational contact with contaminated water and limited awareness of infection risk. This age-related pattern aligns with findings across endemic African regions, where school-aged children are consistently identified as the most vulnerable demographic (Umoh et al., 2020; Mwinzi, 2018). The moderate prevalence among adolescents and adults reflects occupational exposures such as fishing, laundry, and irrigation farming, which sustain transmission cycles within communities.

Sex-related differences showed slightly higher infection rates among males than females, corresponding with their greater participation in water-based activities such as swimming, bathing, and herding livestock. Similar gender-associated exposure patterns have been documented in northern Nigeria (Attah et al., 2023) and Tanzania (Mwinzi, 2018). Marital status and education also influenced infection risk: unmarried and less-educated individuals demonstrated relatively higher prevalence, possibly due to limited access to health information and behavioural guidance on preventive practices. These findings underscore the role of socio-demographic attributes in sustaining schistosomiasis transmission in rural settings.

Occupationally, farmers and fishermen presented higher infection levels than students and traders, reflecting prolonged and frequent contact with natural water bodies. This occupational risk gradient supports WHO's (2023) framework identifying water-based livelihoods as critical exposure determinants. Overall, demographic and behavioural factors jointly reinforce the persistent, low-level transmission observed in the study area despite ecological constraints.

Socio-Behavioural and Sanitation Practices

The persistence of schistosomiasis in Doma LGA is further explained by poor sanitation and risky water-contact behaviour. Field observations revealed widespread open defecation along stream banks, the use of untreated surface water for domestic purposes, and inadequate waste disposal practices. These conditions facilitate continuous contamination of water sources with parasite eggs, sustaining the schistosome life cycle when intermediate hosts are present (WHO, 2023). Moreover, routine bathing, washing, and swimming in local streams were common, particularly among children and farmers, increasing the frequency of human contact with potentially infective cercariae.

This behavioural pattern mirrors reports from other endemic Nigerian communities, where insufficient WASH (Water, Sanitation and Hygiene) infrastructure perpetuates infection despite control interventions (Umoh et al., 2020). The absence of safe water supply systems compels dependence on natural water bodies, while limited health education constrains adoption of protective practices such as water boiling or the use of footwear during irrigation. Addressing these socio-behavioural determinants requires a coordinated approach combining hygiene promotion, sanitation improvement, and community-based education, core principles advocated under WHO's integrated control strategy for neglected tropical diseases.

Immunological and Residency Factors

A notable finding from this study was the higher infection prevalence among residents who had lived in the community for 1–5 years compared to long-term inhabitants. This suggests that immunity acquired through prolonged exposure may confer partial protection against reinfection, as documented in earlier immuno-epidemiological studies (Mwinzi, 2018). Newly settled individuals may lack this adaptive immunity and are therefore more susceptible to infection upon exposure to infested water. The immunological response involves gradual production of protective antibodies and cytokines following repeated cercarial exposure, leading to reduced infection intensity over time (WHO, 2023).

From a public health perspective, this pattern underscores the need to monitor migrant populations and seasonal workers who move between endemic and non-endemic zones. Incorporating residency duration into surveillance and control strategies could enhance precision in targeting high-risk groups. Educational campaigns focusing on preventive behaviour for newcomers would further reduce infection risk. These findings support the inclusion of population mobility in schistosomiasis risk models and highlight migration awareness as a critical component of integrated disease control.

Public Health Implications and Control Strategies

The combined findings of this study, absence of snail hosts, low but persistent urinary schistosomiasis prevalence, and risk concentrated among specific demographic groups, carry important implications for public health planning in Doma LGA. The results suggest that while ecological conditions may currently suppress large-scale transmission, potential remains for re-emergence if environmental and behavioural factors are not addressed. Integrated control strategies should therefore prioritize the following measures:

I. Enhanced WASH infrastructure: Provision of boreholes, improved sanitation facilities, and community hygiene promotion to reduce contamination of surface waters.

II. Targeted Mass Drug Administration (MDA): Periodic praziquantel distribution, particularly to school-aged children and high-risk occupations, in line with WHO (2023) recommendations.

III. Environmental management: Rehabilitation of degraded water bodies and regulation of agricultural runoff to sustain ecological conditions unfavourable for snail proliferation.

IV. Health education and community engagement: Continuous sensitization campaigns focusing on behavioural change, safe water use, and early diagnosis.

V. Surveillance integration: Incorporating ecological monitoring, human infection screening, and migration tracking into routine local health services.

Collectively, these interventions align with Nigeria's National Schistosomiasis Control Strategy, which emphasizes multisectoral coordination involving health, education, and water resources sectors (Onasanya et al., 2023). Strengthening local capacity for environmental and behavioural management remains pivotal for achieving long-term schistosomiasis elimination in the area.

Conclusion

According to this study, schistosomiasis is endemic in nine areas of Nigeria's Doma Local Government Area. Due to seasonal variations, the availability of wells, boreholes, and pipe-borne water, as well as a decrease in activities that could expose people to it, the incidence of Schistosomiasis falls into the low-risk category. Male respondents were more likely than females to get infected, which may be related to their inclination to explore nearby sources of water. The highest prevalence was found in children aged 1–10. Exposure to aquatic bodies is the cause of this. Exposure to water tainted with the parasite's infectious stage, cercariae, is one of several conditions that predispose people to contract *Schistosoma haematobium*, which affects 4.43% of 361 people. 16 people were diagnosed mostly based on microscopic findings in their urine. People who are infected and displaying some schistosomiasis signs require prompt medical attention as well as increased measures to stop the infection's spread or eradicate it.

The main goal of this study is to determine the prevalence of *Schistosoma* species infection in the nine Doma LGA locations that were chosen. This study has demonstrated that, despite the low infection incidence, urinary schistosomiasis exists in Doma LGA. The disease's toxicity and socioeconomic significance necessitate treating afflicted communities in order to slow or halt its spread. To manage schistosomiasis, it is crucial to raise public understanding of the disease's risks and how it is contracted.

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