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Original Article

SPATIAL MAPPING AND RISK FACTOR ANALYSIS OF URINARY SCHISTOSOMIASIS TRANSMISSION IN SCHOOL AGED CHILDREN IN TIKO SUB DIVISION

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ABSTRACT

Introduction: Urinary schistosomiasis caused by *Schistosoma haematobium* remains a Public Health concern among school-aged children in endemic communities of Cameroon. Tiko Sub-Division has documented transmission, but detailed local spatial mapping and risk-factor information is limited.

Objective: The main aim of this study was to determine the prevalence, spatial distribution, and risk factors associated with urinary schistosomiasis among school-aged children in Tiko Sub-Division.

Methods: A school-based cross-sectional study was conducted from November 2025 to July 2026 among 396 children aged 6–16 years recruited from seven health areas. Data were collected using a structured questionnaire and urine laboratory analysis for *S. haematobium eggs*. School GPS coordinates were recorded and analyzed using a geographic information system. Data was analyzed using IBM SPSS version 25.0. Chi square statistical test or Fisher's Exact test were used to assessed associations in the bivariate analysis. Logistic regression was performed for all variables with P values ≤ 0.25 in the bivariate analysis. Statistical significance was set at P value <0.05.

Results: The mean age of study participants was 11.62 ± 1.72 years and male gender predominated the study population. Urinary schistosomiasis prevalence was 7.8% (31/396; 95% CI: 5.16–10.44%). Prevalence ranged from 14.3% in Kange health area to 0.0% in Mudeka health area. No socio-demographic, hygienic, or environmental variable was significantly associated with infection at bivariate analysis ($p > 0.05$). Freshwater visitation was the only independent predictor with children who visited freshwater bodies having higher odds of infection (aOR = 3.24; 95% CI: 1.06–9.76; p = 0.037).

Conclusion: Urinary schistosomiasis remains actively transmitted among school-aged children in Tiko Sub-Division, with marked spatial heterogeneity. Freshwater visitation was independently associated with infection. Spatially targeted surveillance, health education, access to safe water and sanitation, and sustained preventive treatment are warranted in affected areas.

Keywords: Urinary schistosomiasis; Schistosoma haematobium; prevalence; spatial distribution; geographic information system; risk factors; school-aged children; Tiko; Cameroon

INTRODUCTION

Schistosomiasis is a neglected tropical disease caused by parasitic trematode worms transmitted through contact with freshwater in tropical and subtropical regions [1]. Transmission does not occur directly from person to person as it requires freshwater snails that act as obligate intermediate hosts, so effective control depends on interrupting the cycle at both the human and snail stages [2]. Snails of the genera Biomphalaria, Bulinus, and Oncomelania transmit *S. mansoni, S. haematobium,* and *S. japonicum* respectively [3].

In Cameroon, schistosomiasis and soil-transmitted helminthiasis are widely distributed; while mass drug administration (MDA) with mebendazole is implemented nationwide, praziquantel distribution has historically been restricted to a limited number of regions based on mapping conducted around 25 years ago [3]. Urogenital schistosomiasis is caused by infection with *S. haematobium*. Infection occurs when cercariae released by infected Bulinus snails penetrate the skin during contact with contaminated water. Adult female worms deposit terminal-spine eggs in the venous plexuses of the bladder and ureters; some eggs are excreted in urine to continue the parasite's life cycle, while others become trapped in host tissue, provoking immune-mediated inflammation and progressive organ damage [4].

Globally, schistosomiasis is responsible for an estimated 1.43 million disability-adjusted life years lost annually, with over 150,000 deaths attributable to chronic *S. haematobium* infection in Africa [5]. The disease is endemic in 78 countries, with approximately 206.4 million people requiring preventive chemotherapy, 92% of whom reside in Africa [6].

School-aged children are disproportionately affected because of frequent water contact during play, bathing, and household chores, and typically carry the highest infection intensities, sustaining community transmission [7]. Beyond hematuria and dysuria, chronic infection is associated with anemia, growth retardation, cognitive impairment, and long-term urogenital complications including bladder fibrosis, hydronephrosis, and squamous cell carcinoma of the bladder [7].

Geographic information systems (GIS) and spatial mapping have emerged as effective tools for identifying high-risk areas and directing interventions, since schistosomiasis transmission is highly focal and shaped by local snail habitat, water-body characteristics, and human behavior [8].

MATERIALS AND METHODS

Study area and setting

This study was carried out in Tiko Sub Division located in the South West Region of Cameroon. It is a coastal area with rivers, marshes, and irrigated plantations favoring the breeding of Bulinus snails, the intermediate host of *S. haematobium*. The Tiko Health District comprises 84 primary schools distributed across eight health areas: Mutengene, Tiko Town, Likomba, Holforth, Mudeka, Missellele, Mondoni, and Kange.

Study design and Duration

The current study was a school-based cross-sectional study which lasted from November 2025 to July 2026.

Study population and sampling

The study population comprised children aged 6–16 years enrolled in primary schools within the Tiko Health District. A simple random sampling technique was employed to select the primary schools to be included in the study. A primary school was selected from each of the health areas. Probability proportionate to sample size was employed to calculate the number of study participants to be selected per school. A simple random-sampling technique was employed to select the study participants.

Sample size calculation

The minimum sample size was calculated using the Cochran formula for a single proportion given by;

$n = Z^2p(1-p)/d^2$

where; Z = 1.96 (95% confidence level)

P=37% based on a previous study in Tiko [7]

d= 5% which is the margin of accepted error considered in this study. This yielded a minimum sample of 358 participants. After adjusting for an anticipated 10% non-response rate, the final target sample size was 393 children.

Eligibility Criteria

Primary school-going children whose parents/guardians signed the assent form were included in the study. Children who were absent during sample collection, unwilling to participate, or enrolled in confessional primary schools were excluded.

Data collection

A pretested structured questionnaire was used to collect data on socio-demographic characteristics, history of urinary schistosomiasis, water-contact and exposure history, sanitation and hygiene practices, environmental and housing conditions and knowledge of urinary schistosomiasis. GPS coordinates of each selected primary school were recorded using a smartphone GIS application to support spatial mapping.

Laboratory analysis

Urine samples were collected from the children between 8:00 a.m. and 2:00 p.m. Samples were transported to the laboratory for analysis within 60 minutes after collection at ambient temperature (20 – 25C^{O}). Macroscopic examination of all urine samples was performed and urine reagent strips were used to test for hematuria. Ten milliliters of each sample was centrifuged at 1500–3000 rpm for five minutes to obtain the urine sediment. The urine sediment was examined microscopically on a glass slide by 03 independent laboratory scientists. Results were recorded and compared for uniformity. A 4th laboratory scientist was utilized in situations of results discrepancies. *S. haematobium* eggs presented with their characteristic terminal spine.

Data management and analysis

Completed questionnaires were reviewed for completeness, coded and placed in a plastic folder. Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize participant characteristics and infection status. Bivariate associations between candidate risk factors and infection status were assessed using the Pearson chi-square test, with Fisher's exact test applied where expected cell counts were small. Variables were entered into a multivariable logistic regression model to identify independent predictors of infection. Statistical significance was set at $p < 0.05$. GPS coordinates of schools and corresponding prevalence data were imported into QGIS software to map the spatial distribution of infection and visualize transmission hotspots across the health areas of Tiko.

Ethical considerations

This study was approved by the Regional Ethics Committee for Human Health Research, South-West Region, Cameroon (CRERSH-SW), (*Approval No. 158/CRERSH/SW/C/02/2026*).

RESULTS

Socio-demographic and behavioral characteristics

A total of 396 primary school-going children were enrolled from seven health areas within the Tiko Health District. Participants' ages ranged from 6 to 16 years (mean 11.62 ± 1.73 years; median 12.0, IQR 11.0–13.0), and 75.3% were aged 10–13 years. Boys accounted for 52.8% (209/396) and girls for 47.2% (187/396) of participants. Most parents/guardians were farmers (71.2%), followed by traders (15.4%), fishermen (7.1%), and civil servants (6.3%). Most households (72.5%) relied on tap water,

while 22.7% used boreholes and 4.8% used streams. Three-quarters of participants (75.0%) reported visiting freshwater bodies, most commonly for swimming (65.2%), followed by laundry (33.6%) and fishing (9.3%). Weekly contact with water bodies was the most common pattern (46.5%), followed by occasional (34.1%), rare (15.2%), and daily (4.3%) contact. Fewer than half of pupils (48.7%) had previously heard of schistosomiasis (Table 1).

Clinical history and hygienic practices

Overall, 12.9% (51/396) of participants reported a history of hematuria and 12.4% (49/396) reported a prior diagnosis of schistosomiasis, while 93.7% had previously received deworming treatment. With regard to sanitation, 55.1% used pit latrines and 44.9% used water closets. Half of participants (50.3%) reported defecating in water bodies, and 50.5% reported always washing their hands after toilet use; 81.3% had access to soap for hand washing (Table 2).

Prevalence and spatial distribution of urinary schistosomiasis

A total of 31 children tested positive for *Schistosoma haematobium* eggs, giving an overall prevalence of 7.8% (95% CI: 5.16–10.44%); the remaining 365 participants (92.2%) were uninfected (Figure 1).

The prevalence varied markedly across the seven surveyed health areas, demonstrating pronounced spatial heterogeneity in transmission. The highest prevalence was recorded in Kange (14.3%; 7/49), followed by Tiko Town (11.0%; 8/73), Holforth (8.0%; 4/50), Mutengene and Missellele (7.7% each), and Likomba (5.4%; 5/92); no infection was detected among the 41 children examined in Mudeka (Figure 2).

Table 1: Socio-demographic and behavioral characteristics of study participants (n = 396)

Characteristic	Frequency n =396	Percentage (%)
Age group (years)		
06 – 09	44	11.1
10 – 13	298	75.3
14 – 16	54	13.6
Sex		
Male	209	52.8
Female	187	47.2
Parent/Guardian occupation		
Farmer	282	71.2
Fisherman	28	7.1
Trader	61	15.4
Civil servant	25	6.3
Source of household water		
Stream	19	4.8
Borehole	90	22.7
Tap water	287	72.5
Fresh water visitation		
Yes	297	75.0
No	99	25.0
Swimming in water bodies		
Yes	258	65.2
No	138	34.8
Wash clothes in water bodies		
Yes	133	33.6
No	263	66.4
Fishing in water bodies		
Yes	37	9.3
No	359	90.7
Frequency contact with water bodies		
Daily	17	4.3
Weekly	184	46.5
Occasionally	135	34.1
Rarely	60	15.2
Awareness of Schistosomiasis		
Yes	197	48.7
No	199	50.3

Table 2: Clinical history and hygienic practices of study participants (n = 396)

Clinical factors	Frequency (n=396)	Percentage (%)
Hematuria		
Yes	51	12.9
No	341	86.1
No idea	04	1.0
Previous schistosomiasis diagnosis		
Yes	49	12.4
No	336	84.8
No idea	11	2.8
Deworming		
Yes	371	93.7
No	25	6.3
Hygienic practices		
Type of toilet facility		
Water closet	178	44.9
Pit latrine	218	55.1
Defecation in water bodies		
Yes	199	50.3
No	197	49.7
Hand washing after toilet usage		
Always	200	50.5
Sometimes	196	49.5
Availability of soap for hand washing		
Yes	322	81.3
No	74	18.7

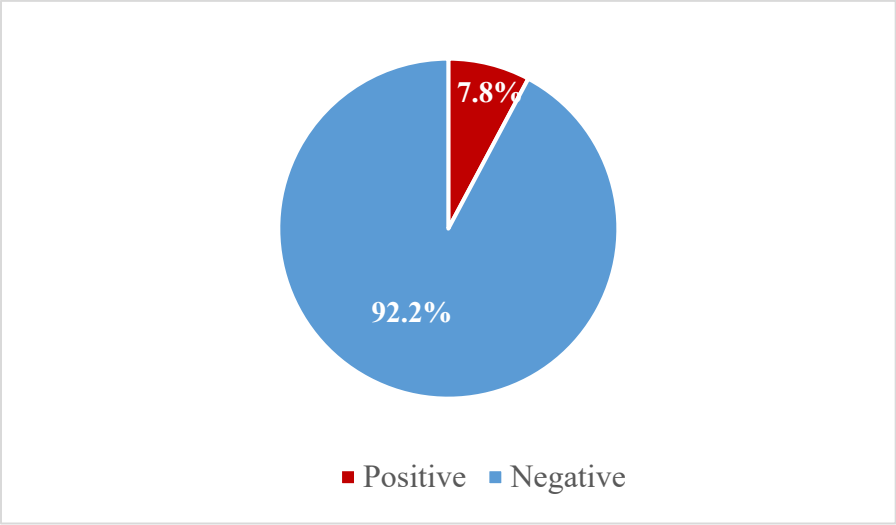
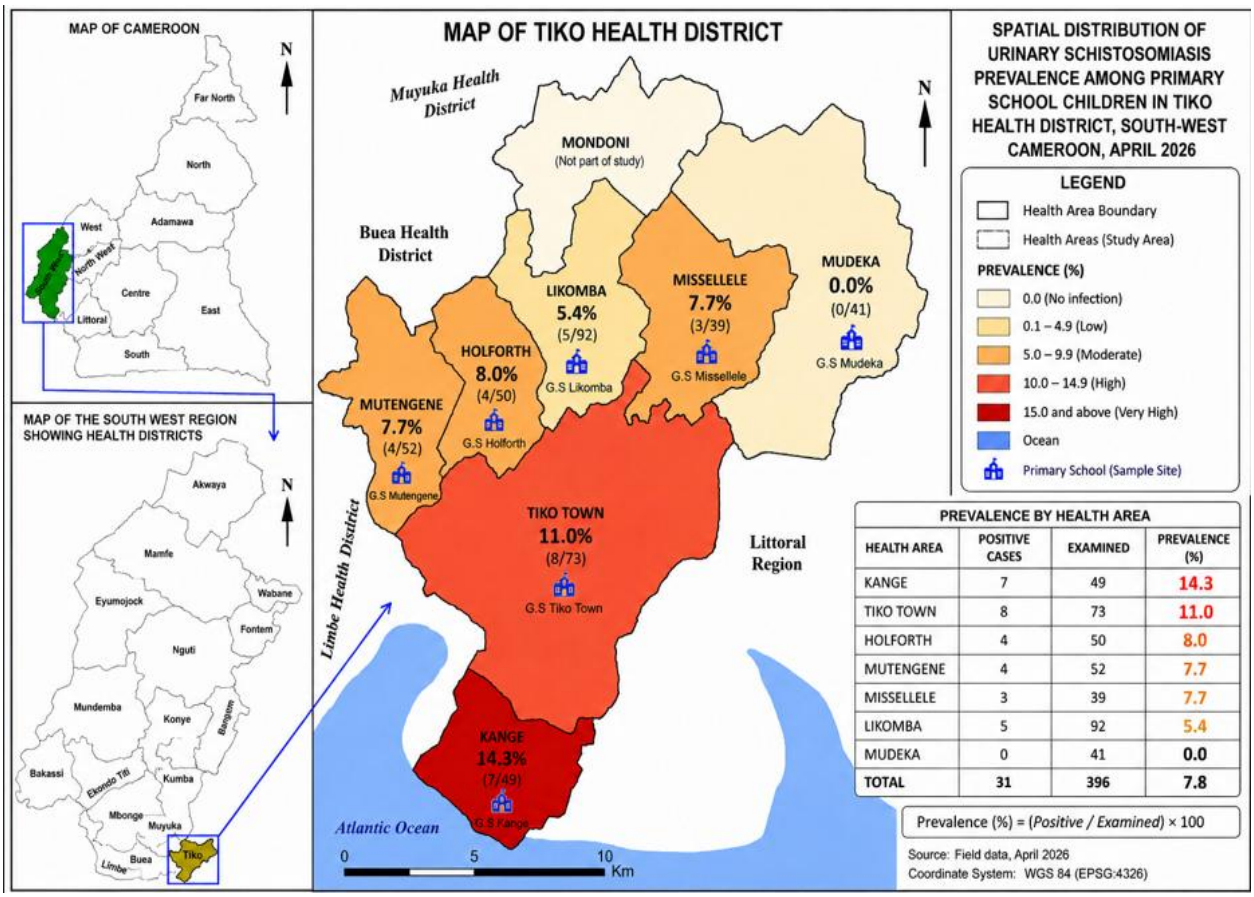


Figure 1: Overall prevalence of urinary schistosomiasis among primary school going children in Tiko, 2026 (n=396)



PREVALENCE BY HEALTH AREA

HEALTH AREA	POSITIVE CASES	EXAMINED	PREVALENCE (%)
KANGE	7	49	14.3
TIKO TOWN	8	73	11.0
HOLFORTH	4	50	8.0
MUTENGENE	4	52	7.7
MISSELLELE	3	39	7.7
LIKOMBA	5	92	5.4
MUDEKA	0	41	0.0
TOTAL	31	396	7.8

Figure 2: Spatial distribution of urinary schistosomiasis prevalence among primary school-going children by health area, Tiko Health District, South-West Cameroon, April 2026

Bivariate analysis of risk factors

None of the socio-demographic characteristics assessed including age group, sex, parent/guardian occupation, or prior awareness of schistosomiasis was significantly associated with infection status (all $p > 0.05$; Table 3).

Similarly, none of the hygienic practice variables examined including toilet facility type, defecation in water bodies, hand-washing frequency, or soap availability was significantly associated with Schistosoma infection (all $p > 0.05$; Table 4).

Table 3: Socio-demographic characteristics associated with urinary schistosomiasis among primary school children in Tiko

Characteristic	Category	Schistosomiasis		X^2 value	Df	*P* value
		Positive n=31 n (%)	Negative n=365 n (%)			
Age group (years)	06-09	03 (9.7)	41 (11.2)			0.903*
	10-13	23 (74.2)	275 (75.3)			
	≥14	05 (16.1)	49 (13.4)			
Sex	Male	15 (48.4)	194 (53.2)	0.260	1	0.610
	Female	16 (51.6)	171 (46.8)			
Parent/Guardian occupation	Farmer	23 (74.2)	259 (71.0)			0.983*
	Fisherman	02 (6.5)	26 (7.1)			
	Trader	04 (12.9)	57 (15.6)			
	Civil servant	02 (6.5)	23 (6.3)			
Awareness of Schistosomiasis	Yes	17 (54.8)	180 (49.3)	0.349	1	0.555
	No	14 (45.2)	185 (50.7)			

**p values calculated using the Fisher's Exact Test*

Table 4: Hygienic practices associated with urinary schistosomiasis among primary school children in Tiko

Practice	Category	Schistosomiasis		X^2 value	Df	*P* value
		Positive n=31 n (%)	Negative n=365 n (%)			
Type of toilet facility	Water closet	18 (58.1)	160 (43.8)	2.34	1	0.126
	Pit latrine	13 (41.9)	205 (56.2)			
Defecation in water bodies	Yes	18 (58.1)	181 (49.6)	0.82	1	0.365
	No	13 (41.9)	184 (50.4)			
Hand washing after toilet usage	Always	20 (64.5)	180 (49.3)	2.64	1	0.104
	Sometimes	11 (35.5)	185 (50.7)			
Availability of soap for hand washing	Yes	27 (87.1)	295 (80.8)	0.74	1	0.390
	No	04 (12.9)	70 (19.2)			

None of the environmental factors assessed including household water source, freshwater visitation, swimming, laundry, or fishing in water bodies, frequency of water contact, stagnant water near the residence, nearby vegetation, or distance to the nearest freshwater source reached statistical significance at the bivariate level (all $p > 0.05$; Table 5), although freshwater visitation showed the strongest trend toward association ($p = 0.105$).

Independent predictors of infection

In multivariable logistic regression, freshwater visitation emerged as the only independent predictor of infection with pupils who visited freshwater bodies being 3.24 times more likely to be infected than those who did not (aOR = 3.24; 95% CI: 1.06–9.76; $p = 0.037$). Toilet facility type and hand-washing frequency, though included in the model, were not independently associated with infection after adjustment (Table 6).

DISCUSSION

This study assessed the prevalence, spatial distribution, and risk factors of urinary schistosomiasis among school-aged children in Tiko Sub-Division. The overall prevalence of 7.8% falls within the World Health Organization's low-endemicity category (<10%), yet the detection of active infections confirms that transmission has not been fully interrupted despite ongoing control measures.

This prevalence is considerably lower than the 37.0% previously reported among school-aged children in Likomba and Upper Costain communities of Tiko Sub-Division [7], the 34.3% reported in the Mount Cameroon area, the 18.0% reported in an earlier Tiko Health District study [9], and the 40.27% documented in Barombi Kotto and Yoke villages of the South-West Region [10]. The prevalence is comparable in magnitude to the 9.3% reported among primary school children in Ghana [11]. The relatively lower prevalence observed here may reflect the cumulative effect of sustained mass drug administration with praziquantel, expanding access to potable water, and ongoing health education in the district; notably, 93.7% of participants in the present study reported previous deworming treatment, a substantially higher coverage than in some earlier surveys.

Table 5: Environmental factors associated with urinary schistosomiasis among primary school children in Tiko

Factor	Category	Schistosomiasis		X^2 value	Df	*P* value
		Positive n=31 n (%)	Negative n=365 n (%)			
Source of household water	Stream	01 (3.2)	18 (4.9)	1.81	2	0.404
	Borehole	10 (32.2)	80 (21.9)			
	Tap	20 (64.5)	267 (73.2)			
Fresh water visitation	Yes	27 (87.1)	270 (74.0)	2.63	1	0.105
	No	04 (12.9)	95 (26.0)			
Swim in water bodies	Yes	22 (71.0)	236 (64.7)	0.50	1	0.479
	No	09 (29.0)	129 (35.3)			
Laundry in water bodies	Yes	11 (35.5)	122 (33.4)	0.05	1	0.816
	No	20 (64.5)	243 (66.6)			
Fishing in water bodies	Yes	03 (9.7)	34 (9.3)	0.01	1	0.947
	No	28 (90.3)	331 (90.7)			
Frequency contact with water bodies	Daily	02 (6.5)	15 (4.1)	1.08	3	0.783
	Weekly	15 (48.4)	169 (46.3)			
	Occasionally	11 (35.5)	124 (34.0)			
	Rarely	03 (9.7)	57 (15.6)			
Stagnant water around residence	Yes	09 (29.0)	145 (39.7)	1.38	1	0.241
	No	22 (71.0)	220 (60.3)			
Nearby residence vegetation	Yes	17 (54.8)	234 (64.1)	1.06	1	0.304
	No	14 (45.2)	131 (35.9)			
Distance to nearby fresh water source	<500 m	08 (25.8)	92 (25.2)	2.57	2	0.241
	500m to 1 km	18 (58.1)	244 (66.8)			
	>1 km	05 (16.1)	29 (7.9)			

Table 6: Predictors of urinary schistosomiasis infection among primary school going children in Tiko

Predictor	Category	Schistosomiasis		cOR (95% CI)	*P* value	aOR (95% CI)	*P* value
		Positive (n)	Negative (n)				
Type of toilet facility	Water closet	18	160	1		1	
	Pit latrine	13	205	0.56 (0.27-1.19)	0.130	0.53 (0.25-1.14)	0.103
	Total	31	365				
Hand washing after toilet usage	Always	20	180	1		1	
	Sometimes	11	185	0.54 (0.25-1.15)	0.109	0.49 (0.23-1.08)	0.078
	Total	31	365				
Fresh water visitation	Yes	27	270	2.34 (0.81-6.96)	0.115	3.24 (1.06-9.76)	**0.037**
	No	04	95	1		1	
	Total	31	365				

P values <0.05 are statistically significant

This is consistent with reports elsewhere in Cameroon describing a decline in schistosomiasis prevalence following repeated preventive chemotherapy campaigns [12]. Nonetheless, continued detection of infection including in previously less-affected areas indicates that human water contact continues to sustain transmission even where chemotherapy coverage is high.

Marked spatial heterogeneity was observed across the seven surveyed health areas, with Kange, Tiko Town, and Holforth recording the highest prevalence, and Mudeka recording no infection. This focal distribution pattern is characteristic of schistosomiasis epidemiology, in which transmission intensity is governed largely by the local availability of suitable snail habitat and the frequency of human contact with infested water. The comparatively higher prevalence in Kange may reflect greater reliance on freshwater bodies for domestic, recreational, or occupational activities in that community. Similar clustering of infection around water-contact points has been documented elsewhere in the Mount Cameroon area, where infections concentrated in communities with frequent freshwater exposure. Conversely, the absence of

infection in Mudeka may reflect environmental conditions less conducive to snail breeding, lower snail density, or reduced water-contact behavior in that area, consistent with prior Cameroonian studies reporting substantially lower prevalence in communities with limited water exposure [12]. These spatial findings reinforce the utility of GIS-based mapping for prioritizing surveillance, snail control, health education, and preventive chemotherapy toward specific high-risk health areas rather than applying uniform, district-wide interventions.

Freshwater visitation was identified as the only independent predictor of infection in multivariable analysis, a finding consistent with the well-established transmission pathway of *S. haematobium*, in which cercariae released by infected Bulinus snails penetrate the skin during water contact. This aligns with previous reports from Tiko and elsewhere in the South-West Region identifying water contact as the principal driver of infection [7, 9]. Conversely, no significant association was found between infection and hygiene-related variables toilet type, hand-washing frequency, or soap availability a biologically plausible finding, since urinary schistosomiasis is acquired through dermal cercarial penetration rather than fecal–oral transmission. This mirrors observations from an earlier study conducted in Tiko [7].

Conclusion

Urinary schistosomiasis remains endemic among school age children in Tiko health district, with an overall prevalence of 7.8%. Infection was unevenly distributed with Kange, Tiko town and Holforth health areas identified as priority transmission hot spots. Fresh water contact was the only independent predictor of infection on multivariable analysis. Continued targeted intervention, including mass drug administration, health education, improve water sanitation, hygiene facilities and geographical information system surveillance are recommended.

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Conflict of interest

The authors declare no conflict of interest as regards the publication of this manuscript.

Declaration of AI use

The authors declare that Artificial intelligence tool (Chat GPT) was used during the preparation of this manuscript to assist with language editing, grammar, clarity, and organization of the written content. AI was

not use to generate, alter, or analyze the study findings. The authors review and take full responsibility for the final content of the manuscript.

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