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Adolescents and young adults excluded from preventive chemotherapy for schistosomiasis control in Northern Tanzania: are they at risk and reservoirs of infection? Prevalence and determinants of transmission in Northern Tanzania

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ABSTRACT

Objective: To investigate the magnitude of urogenital schistosomiasis and determinants of transmission among adolescents and young adults in Itilima district, Simiyu region, Northern Tanzania.
Methods: A quantitative cross-sectional study was carried out using probability sampling strategies to select 433 secondary school students from five schools among the five wards of Itilima district, an area endemic for urogenital schistosomiasis. A self-administered structured questionnaire was used to gather data on determinants, and urine samples were examined for macrohaematuria and the presence of *Schistosoma haematobium* using the standard urine filtration technique. Data analysis was performed using descriptive statistics, Chi-squared test and logistic regression.
Results: The overall prevalence rates of *S. haematobium* infection and macrohaematuria among adolescents and young adults were 15.9% and 3%, respectively, with the majority of individuals being lightly infected (85.5%). The determinants for urogenital schistosomiasis among the adolescents and young adults in Itilima district were: being in Form I [adjusted odds ratio (aOR) 2.42, 95% confidence interval (CI) 1.16–11.8; *P*=0.018]; being resident in Sasago ward (aOR 5.57, 95% CI 1.98–15.67; *P*=0.001) or Budalabujiga ward (aOR 2.99, 95% CI 1.04–8.56; *P*=0.042); having positive attitudes towards urogenital schistosomiasis (aOR 3.14, 95% CI 1.27–7.72; *P*=0.013); swimming in rivers (aOR 1.92, 95% CI 1.06–3.50; *P*=0.032); and urinating in water bodies (aOR 1.68, 95% CI 1.05–2.69; *P*=0.032).
Conclusions: Urogenital schistosomiasis is prevalent among adolescents and young adults, and serves as a reservoir for transmission of *S. haematobium*. Preventive chemotherapy campaigns should be extended to adolescents and young adults, and integrated with regular screening, health education and an adequate water supply.

Introduction

Urogenital schistosomiasis ranks as the second most common parasitic infection of socio-economic and public health importance in sub-Saharan Africa. Approximately 112 million people are infected worldwide, and 93% are from sub-Saharan Africa (World Health Organization, 2019). Infection occurs from exposure to cercaria-infested water during domestic, agricultural and recreational activities (World Health Organization, 2019). The highest prevalence and intensity of urogenital schistosomiasis have been observed in school-aged children, adolescents and young adults, with most cases of infection seen in individuals aged 5–15 years (Richardson *et al.*, 2016). Infected individuals experience haematuria and other associated pathological complications, such as dysuria, anaemia, nutritional deficiencies and growth retardation (Mazigo *et al.*, 2012). These complications affect cognitive development, and reduce physical activity, school performance and work capacity among the vulnerable population (pre- and school-aged children) (Senghor *et al.*, 2014). Infection increases the risk of bladder cancer and cervical can-

Abbreviations: MDA, Mass Drug Administration; NTDs, Neglected Tropical Diseases; *S. haematobium*, *Schistosoma haematobium*; WaSH, Water, Sanitation and Hygiene; WHO, World Health Organization.

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cer, especially among women with female genital schistosomiasis and human immunodeficiency virus (Hotez *et al.*, 2020).

Urogenital schistosomiasis is common in communities with a poor water supply, poor sanitation and poor hygiene practices (Grimes *et al.*, 2014). Contamination of the water source by unhygienic practices, coupled with the presence of a suitable intermediate host (*Bulinus* snails), perpetuates transmission (Mushi *et al.*, 2022a). Also, there is evidence of an association between low knowledge, negative attitudes and inappropriate water, sanitation and hygiene (WaSH) practices towards the disease and increased disease transmission rates (Folefac *et al.*, 2018; Angelo *et al.*, 2019; Mushi *et al.*, 2022b). Several control interventions have been implemented to minimize prevalence, intensity of infection, morbidity and praziquantel distribution, with mass drug administration (MDA) being the principal intervention (Cribb *et al.*, 2019). However, the MDA with praziquantel intervention targets primary school children, and excludes other vulnerable populations including young adults and adolescents (Richardson *et al.*, 2016; Cribb *et al.*, 2019). Populations that remain untreated continue to suffer from urogenital schistosomiasis, and serve as reservoirs of infection in the community.

In Tanzania, *Schistosoma haematobium* is endemic throughout most of the country; however, it is most prevalent along the coast and shores of Lake Victoria (Mazigo *et al.*, 2012). As in other endemic countries, the prevalence of urogenital schistosomiasis differs between age groups, occupations and genders (Mazigo *et al.*, 2012). In Tanzania, the distribution of preventive chemotherapy with praziquantel started in 2006, targeting primary school children (Neglected Tropical Disease Control Program in Tanzania 2016). Unfortunately, once a child leaves primary school, they no longer receive preventive chemotherapy with praziquantel despite continued exposure to cercariae-infested water in urogenital-schistosomiasis-endemic regions. Despite national and international efforts to interrupt the transmission of urogenital schistosomiasis, the disease remains endemic in Itilima district, with prevalence of 10.1% reported recently among school-aged children (Mazigo, 2020). As the world moves towards the elimination phase, the new World Health Organization (WHO)-endorsed Neglected Tropical Disease (NTD) road map urges improvement of interventions, including the extension of preventive chemotherapy to groups excluded from existing programmes (World Health Organization, 2019). Unfortunately, there is a scarcity of epidemiological data regarding the burden and determinants of urogenital schistosomiasis among adolescents and young adults, both in and out of schools, who are not the target population of the MDA programmes. As such, this study aimed to investigate the magnitude and determinants of urogenital schistosomiasis among secondary school students in Itilima district. The information obtained will be useful in long-term interventions, as the new WHO road map on NTDs, particularly the schistosomiasis section, urges extending the control programme to an elimination programme.

Materials and methods

Study area and demographics

The study area was Itilima district. This district is one of five districts in the Simiyu region of Tanzania in East Africa. Itilima district is bordered to the north by Bariadi district, bordered to the east by Ngorongoro district (Arusha region), bordered to the south by Maswa and Meatu districts, and bordered to the west by Magu district (Mwanza region) (PORALG-Itilima District Council, 2022). Itilima district was established in 2012 when it was split off from Bariadi district and became part of the newly established Simiyu region. Itilima district lies at latitude 3°44′0″ south and longitude 33°29′0″ east (PORALG-Itilima District Council, 2022). There are 22 wards with 102 villages in Itilima district, and an approximate population of 313,900 (165,398 females and 148,502 males) (National Bureau of Statistics, 2013).

Itilima district has annual rainfall of 930–1200 mm and temperatures of 25–28°C. This district was selected for this study because of its history of a high prevalence of urogenital schistosomiasis in primary school children (Clements *et al.*, 2008; Mazigo, 2020). The available data indicate that *S. haematobium* is endemic in Itilima district, despite more than a decade of praziquantel distribution (Mazigo, 2020). This could be due to the presence of several dams and seasonal streams that favour breeding and survival of *Bulinus* snails (intermediate host for urogenital schistosomiasis). Five of eight wards in Itilima district with high prevalence of urogenital schistosomiasis among school-aged children were included in this study (Figure 1). These wards were: Sagata ward (9.8%), Nkoma ward (11.1%), Ndoleji ward (18%), Budalabujiga ward (26%) and Sasago ward (57.9%) (Mazigo, 2020).

Figure 1. Administrative map of Itilima district, with blue shading showing the five selected wards (Sagata, Ndoleleji, Budalabujiga, Nkoma and Sasago/Zagayu wards).

Study design and population

A school-based cross-sectional study employing quantitative methods of data collection was carried out in Itilima district from May to June 2021 to investigate the burden of urogenital schistosomiasis and its determinants among secondary school students. The study population was secondary school students attending selected schools located in endemic areas of Itilima district. The inclusion criteria were: age 13–22 years, and resident in the study area for ≥6 months preceding the study. Girls who were menstruating on the day of data collection and students with a history of praziquantel uptake in the 6 months preceding data collection were excluded.

Sample size determination and sampling

In total, 433 secondary school students were recruited into this study. The sample size was estimated using the Creswell formula for cross-sectional studies [$n = z^2\ P\ (100\text{-}P)/\varepsilon^2$] (Creswell, 2007), set for a standard normal deviate of 1.96 using a 95% confidence interval (CI), proportion of 10.1% (Mazigo, 2020) and margin of error of 3%; the sample size was subsequently adjusted for 10% of the non-response rate. Probability sampling was employed where a two-stage-stratified cluster sampling procedure was used to select secondary schools and students to participate in this study. In the first stage, five of eight wards with prevalence of urogenital schistosomiasis >5% were selected at random. In the second stage, five of 10 secondary schools were selected at random from the five wards. In the final stage, students were selected at random, with the number selected from each school being proportional to the size of the school. For each school, the population was classified into four strata based on form (Forms I–IV).

Sample collection and processing

Students were given labelled containers for urine collection (single sample) after the questionnaire interview. The students were instructed to provide at least 30 mL of urine between 10:00 am and 2:00 pm (optimum time for shedding *S. haematobium* eggs). All collected samples were examined macroscopically for macrohaematuria (presence of visible blood). Next, the urine filtration technique was used for microscopic examination of *S. haematobium* eggs, as described by Cheesbrough (2006). For each urine sample collected, 10 mL was drawn using a plastic syringe and pushed through a polycarbonate filter with a membrane pore size of 12 μm (Costar Corp., USA). All filters were placed on microscope glass slides, followed by a drop of Lugol's iodine, and examined microscopically (X40 magnification). For positive samples, the infection load was recorded as the number of eggs per 10 mL of urine.

Questionnaire survey

A pretested self-administered structured questionnaire in Kiswahili was used to gather information from selected participants. The questionnaire consisted of Sections 1–5. Section 1 collected sociodemographic characteristics. Section 2 collected information on the history of praziquantel uptake. Section 3 assessed the WaSH practices of the students. Section 4 assessed awareness and knowledge. Section 5 assessed attitudes towards urogenital schistosomiasis among secondary school students.

Quality control

The questionnaire was pretested at Itilima Secondary School in Luguru ward with 43 students (10% of the sample size). Luguru ward was not one of the wards sampled for data collection. Each urine sample collected was examined twice (once by two laboratory technologists) for quality control of the urogenital schistosomiasis results. Ten percent (n=43) of urine samples were selected at random and examined by the researcher for verification of the microscopic results. In the case of discrepancy regarding the presence or absence of *S. haematobium* eggs, the researcher repeated the processing of the urine sample and microscopic examination. The intensity of *S. haematobium* infection was based on the average number of *S. haematobium* eggs reported by the two laboratory technologists.

Data analysis

Data were checked for completeness, double entered into Epi-Data Version 3.1 (EpiData Association, Odense, Denmark), and exported into SPSS Version 23 (IBM Corp, Armonk, NY, USA) for analysis. Categorical variables were summarized as frequency/proportion and 95% CI, and continuous data were summarized as mean ± standard deviation. The prevalence rates of *S. haematobium* and macrohaematuria were summarized based on their sociodemographic characteristics. The intensity of infection was summarized as the geometric mean egg output per 10 mL of urine. Based on WHO criteria for the classification of infection load, infection was classified as light (1–50 eggs/10 mL) or heavy (≥51 eggs/10 mL of urine) (World Health Organization, 2002). The frequencies and proportions of categorical variables were compared using Pearson's Chi-squared test, with P<0.05 considered to indicate significance. Univariate logistic regression was employed to assess the determinants of urogenital schistosomiasis among secondary school students, and independent variables with P<0.2 were subjected to multivariate analysis.

In total, six questions with eight responses were used to assess knowledge levels. A scoring scale was used for analysis, whereby an incorrect answer scored 0 and a correct answer scored 1. The total score for each student was calculated, and scores ≤4, 5–6, and ≥7 were classified as low, moderate and high knowledge, respectively. Six statements assessed students' attitudes towards urogenital schistosomiasis, and five questions were used to assess practices. Attitude statements were scored, followed by the sum calculation of attitudes.

Table 1
Sociodemographic characteristics of study participants (n=433).

Variable	n (%)	95% CI
Sex		
Male	214 (49.4)	44.1–53.8
Female	219 (50.6)	46.2–55.9
Age group	17 (range 13–21)	
Early adolescents (13–15)	84 (19.4)	15.4–23.3
Late adolescents (16–18 years)	283 (65.4)	61.2–69.7
Young adults (19–21 years)	66 (15.2)	11.7–18.9
Form		
I	126 (29.1)	24.7–33.9
II	110 (25.4)	21.2–29.8
III	98 (22.6)	18.9–26.6
IV	99 (22.9)	18.2–26.6
Ward of residency and school		
Sagata (Sagata Primary School)	93 (21.5)	18.0–25.4
Ndoleleji (Ndoleleji Primary School)	78 (18.0)	14.5–21.7
Budalabujiga (Budalabujiga Primary School)	82 (18.9)	15.5–22.4
Nkoma (Nkoma Primary School)	86 (19.9)	16.4–23.3
Sasago (Sasago Primary School)	94 (21.7)	18.0–25.6

CI, confidence interval.

Based on the mean score (11.94), those who scored ≥13 and ≤12 for attitudes were categorized as having positive or negative attitudes, respectively. For practices, the responses were summarized into frequencies and proportions.

Operational definitions of key terms

Urogenital schistosomiasis was defined as the existence of *S. haematobium* eggs in urine samples. Intensity of infection was defined as the number of *S. haematobium* eggs per 10 mL of urine. Adolescence was defined as the transition period between childhood and adulthood, and was classified as early adolescents (13–15 years), late adolescents (16–18 years) and young adults (19–21 years). Attitudes was defined as an individual's point of view about urogenital schistosomiasis, classified as positive or negative based on the mean score.

Results

Sociodemographic characteristics of study participants

Of the 433 secondary students included in this study, half (50.6%) were females and nearly two-thirds (65.4%) were late adolescents. The median age was 17 years, with an age range of 13–21 years (Table 1).

Prevalence of urogenital schistosomiasis and macrohaematuria among secondary school students

The overall prevalence rates of urogenital schistosomiasis and macrohaematuria were 15.9% and 3%, respectively. The prevalence of urogenital schistosomiasis was high among males (16.8%), late adolescents (age 16–18 years) (17.7%), students in Form I (19%), and students residing in Sasago ward (35.1%). The prevalence of macrohaematuria was high among males (3.3%), early adolescents (age 13–15 year) (6%), students in Form II (4.5%), and residents of Sasago ward (9.6%). Significant differences in the prevalence rates of urogenital schistosomiasis (P<0.000) and macrohaematuria (P=0.001) were found between the wards of residence (Table 2).

Intensity of urogenital schistosomiasis among secondary school students

Of the 69 students who were positive for *S. haematobium*, 59 (85.5%, 95% CI 73.6–92.9) had light infection and 10 (14.5%, 95% CI 7.1–26.4)

Table 2
Prevalence of urogenital schistosomiasis and macrohaematuria according to sociodemographic characteristics of secondary school students (*n*=433).

Sociodemographics	Total	Prevalence of *Schistosoma haematobium* *n* (%)	*P*-value	Prevalence of macrohaematuria *n* (%)	*P*-value
Sex					
Male	214	36 (16.8)	0.618	7 (3.3)	0.746
Female	219	33 (15.1)		6 (2.7)	
Age group					
Early adolescents (13–15 years)	84	14 (16.7)	0.128	5 (6.0)	0.194
Late adolescents (16–18 years)	283	50 (17.7)		7 (2.5)	
Young adults (19–21 years)	66	5 (7.6)		1 (1.5)	
Class					
Form I	126	24 (19)	0.448	5 (4.0)	0.397
Form II	110	18 (16.4)		5 (4.5)	
Form III	98	16 (16.3)		2 (2.0)	
Form IV	99	11 (11.1)		1 (1.0)	
Ward of residency and school					
Sagata (Sagata Primary School)	93	9 (9.7)	0.000[a]	2 (2.2)	0.001[a]
Ndoleleji (Ndoleleji Primary School)	78	4 (5.1)		0 (0.0)	
Budalabujiga (Budalabujiga Primary School)	82	13 (15.9)		2 (2.4)	
Nkoma (Nkoma Primary School)	86	10 (11.6)		0 (0.0)	
Sasago (Sasago Primary School)	94	33 (35.1)		9 (9.6)	

[a] Significant ($P<0.05$).

Table 3
Classification of the intensity of urogenital schistosomiasis according to sociodemographic characteristics (*n*=433).

Sociodemographics	Total	Classification of intensity		*P*-value
		Light	Heavy	
Sex				
Male	36	30 (83.3)	6 (16.7)	0.591
Female	33	29 (87.9)	4 (12.1)	
Age group				
Early adolescents (13–15 years)	14	9 (64.3)	5 (35.7)	0.034[a]
Late adolescents (16–18 years)	50	45 (90.0)	5 (10.0)	
Young adults (19–21 years)	5	5 (100)	0 (0.0)	
Form				
I	24	19 (79.2)	5 (20.8)	0.112
II	18	14 (77.8)	4 (22.2)	
III	16	15 (93.8)	1 (6.2)	
IV	11	11 (100)	0 (0.0)	
Ward of residency and school				
Sagata (Sagata Primary School)	9	8 (88.9)	1 (11.1)	0.235
Ndoleleji (Ndoleleji Primary School)	4	4 (100)	0 (0.0)	
Budalabujiga (Budalabujiga Primary School)	13	11 (84.6)	2 (15.4)	
Nkoma (Nkoma Primary School)	10	10 (100)	0 (0.0)	
Sasago (Sasago Primary School)	33	26 (78.8)	7 (21.2)	

[a] Significant ($P<0.05$).

had heavy infection. The geometric mean egg count was 8.8715 per 10 mL of urine (95% CI 6.04–13.73), with the number of eggs ranging from 1 to 407. Heavy infection was observed among males (16.7%), early adolescents (35.7%) and students in Form II (22.2%), with a significant difference in the intensity of infection between age groups ($P=0.034$) (Table 3).

History of self-reported uptake of praziquantel among study participants

The majority of students (94.2%) reported ever taking praziquantel, with nearly half (46.3%) participating in two rounds of preventive chemotherapy with praziquantel during their time at primary school (Table 4).

Knowledge about urogenital schistosomiasis among study participants

All of the study participants had heard of urogenital schistosomiasis. However, only a few (3.6%) knew the correct mode of transmission of urogenital schistosomiasis. All of the participants knew that urogenital schistosomiasis is preventable, with the most commonly mentioned method of prevention being avoidance of contact with unprotected water sources (82.4%) (Table 5). Seven (1.6%, 95% CI 0.5–3.0) participants had low knowledge, 153 (35.3%, 95% CI 30.9–40.0) participants had moderate knowledge, and 273 (63%, 95% CI 58.7–67.7) participants had high knowledge.

Table 4
Self-reported history of use of praziquantel among study participants (*n*=433).

Variable	*n* (%)	95% CI
Ever taken praziquantel		
Yes	408 (94.2)	91.2–96.8
No	25 (5.8)	3.2–8.8
Rounds of praziquantel		
1	139 (34.1)	29.9–98.6
2	189 (46.3)	41.8–50.9
3	73 (17.9)	14.3–21.7
≥4	7 (1.7)	0.7–3.4
Most recent use of praziquantel		
≤6 months	10 (2.5)	1.0–4.4
≤12 months	92 (22.5)	19.5–26.7
≥13 months	306 (75.0)	70.9–79.5

CI, confidence interval.

Table 5
Knowledge about urogenital schistosomiasis among study participants (*n*=433).

Variable	*n* (%)	95% CI
Heard of urogenital schistosomiasis?		
Yes	433 (100)	
No		
Source of information		
School	280 (64.7)	60.0–69.1
Social media	20 (4.6)	2.8–6.7
Health centre	99 (22.9)	19.2–26.8
Mass media (television, radio and magazines)	28 (6.5)	4.6–9.0
Friends	6 (1.4)	0.5–2.5
Mode of transmission of urogenital schistosomiasis		
Contact with infested water	161 (37.2)	32.5–41.8
Eating contaminated food	12 (2.8)	1.2–4.6
Poor personal hygiene	243 (56.1)	51.5–61.0
Drinking untreated water|	17 (3.9)	2.1–5.8
Signs of urogenital schistosomiasis		
Blood in urine	176 (40.6)	35.3–45.3
Painful urination	236 (54.5)	49.9–59.4
Stomach ache	10 (2.3)	1.2–3.7
Swollen abdomen	5 (1.2)	0.2–2.3
Do not know	6 (1.4)	0.5–2.5
Is schistosomiasis treatable?		
Yes	426 (98.4)	97.0–99.5
No	7 (1.6)	0.5–3.0
Ways to treat urogenital schistosomiasis		
Modern (hospital) treatment	409 (96.0)	94.1–97.7
Traditional medicine	6 (1.4)	0.5–2.6
Do not know	11 (2.6)	1.2–4.2
Is schistosomiasis preventable?		
Yes	433 (100)	
No		
Ways to prevent urogenital schistosomiasis		
Avoiding contact with unprotected water sources	357 (82.4)	78.3–85.9
Using preventive chemotherapy	42 (9.7)	6.9–12.7
Using piped water	23 (5.3)	3.2–7.6
Improving personal hygiene	8 (1.8)	0.7–3.2
Always using latrines	3 (0.7)	0.0–1.8

CI, confidence interval.

Table 6
Classification of knowledge levels according to sociodemographic characteristics (*n*=433).

Sociodemographics	Total	Level of knowledge			*P*-value
		Low	Moderate	High	
Sex					
Male	214	2 (0.9)	73 (34.1)	139 (65.0)	0.445
Female	219	5 (2.3)	80 (36.5)	134 (61.2)	
Age group					
Early adolescents (13–15 years)	84	2 (2.4)	38 (45.2)	44 (52.4)	0.158
Late adolescents (16–18 years)	283	3 (1.1)	95 (33.6)	185 (65.4)	
Young adults (19–21 years)	66	2 (3.0)	20 (30.3)	44 (66.7)	
Form					
I	126	2 (1.6)	52 (41.3)	72 (57.1)	0.751
II	110	2 (1.8)	35 (31.8)	73 (66.4)	
III	98	2 (2.0)	31 (31.6)	65 (66.3)	
IV	99	1 (1.0)	35 (35.4)	63 (63.6)	
Ward of residency and school					
Sagata (Sagata Primary School)	93	2 (2.2)	41 (44.1)	50 (53.8)	0.132
Ndoleleji (Ndoleleji Primary School)	78	1 (1.3)	25 (32.1)	52 (66.7)	
Budalabujiga (Budalabujiga Primary School)	82	1 (1.2)	30 (36.6)	51 (62.2)	
Nkoma (Nkoma Primary School)	86	3 (3.5)	33 (38.4)	50 (58.1)	
Sasago (Sasago Primary School)	94	0 (0.0)	24 (25.5)	70 (74.5)	

Table 7
Classification of attitudes according to sociodemographic characteristics (*n*=433).

Sociodemographics	Total	Attitude		*P*-value
		Positive	Negative	
Sex				
Male	214	169 (79.0)	45 (21.0)	0.004[a]
Female	219	146 (66.7)	73 (33.0)	
Age group				
Early adolescents (13–15 years)	84	55 (65.5)	29 (34.5)	0.241
Late adolescents (16–18 years)	283	210 (74.2)	73 (25.8)	
Young adults (19–21 years)	66	50 (75.8)	16 (24.2)	
Form				
I	126	89 (70.6)	37 (29.4)	0.412
II	110	76 (69.1)	34 (30.9)	
III	98	72 (73.5)	26 (26.5)	
IV	99	78 (78.8)	21 (21.2)	
Ward of residency and school				
Sagata (Sagata Primary School)	93	56 (60.2)	37 (39.8)	0.000
Ndoleleji (Ndoleleji Primary School)	78	65 (83.3)	13 (16.7)	
Budalabujiga (Budalabujiga Primary School)	82	63 (76.8)	19 (23.2)	
Nkoma (Nkoma Primary School)	86	49 (57.0)	37 (43.0)	
Sasago (Sasago Primary School)	94	82 (87.2)	12 (12.8)	

[a] Significant (P<0.05).

Classification of knowledge levels according to sociodemographic characteristics

A high level of knowledge was found in males (65%), young adults (66.7%), students in Form II (66.4%) and residents of Sasago ward (74.5%). No significant differences were found between level of knowledge and the sociodemographic characteristics of the participants (Table 6).

Attitudes about urogenital schistosomiasis among study participants

Overall, 45.3% of the participants felt that urogenital schistosomiasis is a health problem of low priority. The vast majority (90.8%) of participants were against the isolation of individuals with urogenital schistosomiasis (Figure 2). Of the 433 participants, 315 (72.7%, 95% CI 68.1–76.9) had positive attitudes towards urogenital schistosomiasis, and 118 (27.3%, 95% CI 23.1–31.9) had negative attitudes towards urogenital schistosomiasis.

Classification of attitude levels according to sociodemographic characteristics

Negative attitudes were observed among females (33%), early adolescents (34.5%), students in Form II (30.9%) and residents of Nkoma ward (43.0%). Significant differences were observed in attitudes between sexes (P=0.004) and wards of residency (P<0.000) (Table 7).

Water practices of study participants

A high prevalence of *S. haematobium* was observed among participants who reported using river water as the water source at home (29.6%), swimming (18.4%), swimming in lakes (75%), and urinating in water bodies (35.2%). A significant association was found between the prevalence of urogenital schistosomiasis and the water source at home (P=0.024), swimming (P=0.015), water body used for swimming (P<0.000), and urinating in water bodies (P<0.000) (Table 8).

Determinants of transmission of urogenital schistosomiasis among study participants

The determinants for urogenital schistosomiasis in the multivariate logistic analysis were being a student in Form I [adjusted odds ratio

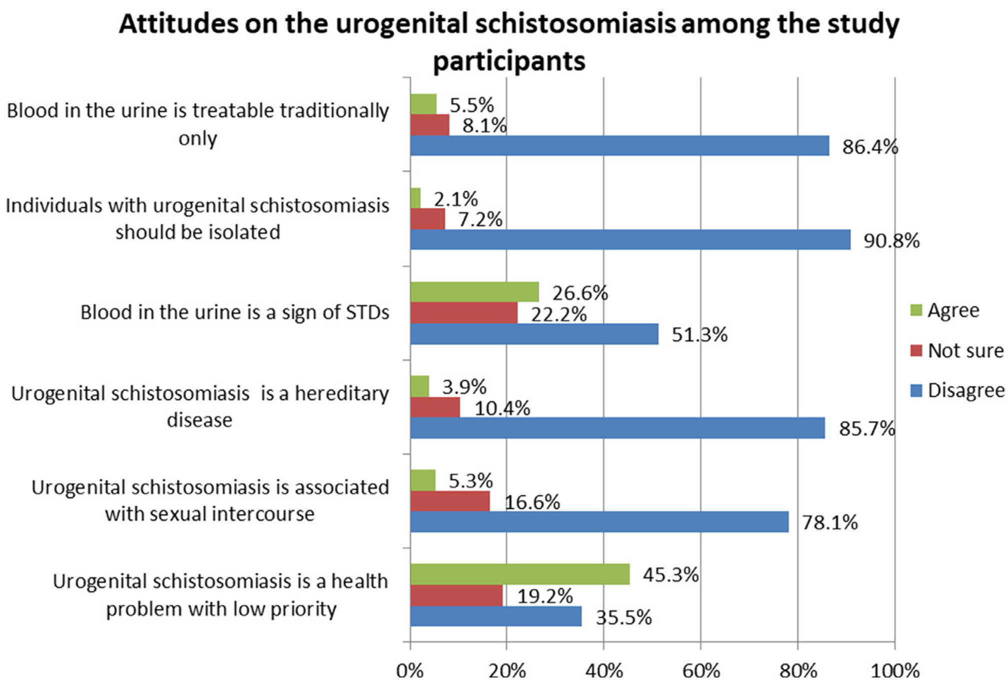

Figure 2. Attitudes about urogenital schistosomiasis among study participants.

Table 8
Water practices of study participants (n=433).

Variable	n (%)	*Schistosoma haematobium* positive	P-value
Source of water used at home			
Piped water	280 (64.7)	39 (13.9)	0.024[a]
River water	54 (12.5)	16 (29.6)	
Lake and spring	99 (22.9)	14 (14.9)	
Swimming			
Yes	309 (71.4)	57 (18.4)	0.015[a]
No	124 (28.6)	12 (9.7)	
Water body used for swimming			
River	237 (76.7)	32 (13.5)	0.000[a]
Spring	64 (20.7)	19 (29.7)	
Lake	8 (1.8)	6 (75.0)	
Urinating in water bodies			
Yes	71 (16.4)	25 (35.2)	0.000[a]
No	362 (83.6)	44 (12.2)	
Farming near water sources			
Yes	409 (94.5)	67 (16.4)	0.295
No	24 (5.5)	2 (8.3)	
Fishing			
Yes	178 (41.1)	34 (19.1)	0.086
No	255 (58.9)	35 (13.7)	

[a] Significant (P<0.05).

(aOR) 2.42, 95% CI 1.16–11.8; P=0.018], being resident in Sasago ward (aOR 5.57, 95% CI 1.98–15.67; P=0.001) or Budalabujiga ward (aOR 2.99, 95% CI 1.04–8.56; P=0.042), having positive attitudes towards urogenital schistosomiasis (aOR 3.14, 95% CI 1.27–7.72; P=0.013), swimming in rivers (aOR 1.92, 95% CI 1.06–3.50; P=0.032), and urinating in water bodies (aOR 1.68, 95% CI 1.05–2.69; P=0.032) (Table 9).

Discussion

This study is one of few to establish the magnitude and determinants of urogenital schistosomiasis among adolescents and young adults in Itilima district, Simiyu region, Tanzania. The study found an overall prevalence of *S. haematobium* infection of 15.9% among adolescents and young adults (secondary school students), compared with 10.1% among primary school children in Itilima district (Mazigo, 2020). The higher prevalence of urogenital schistosomiasis among secondary school students is due to the absence of a praziquantel preventive chemotherapy programme targeting this group. The prevalence observed in this study was low compared with studies from Nigeria (22.7% and 55.1%) (Atalabi *et al.*, 2016; Ojo *et al.*, 2021). The prevalence of *S. haematobium* infection varied with age group, but the differences were not significant. The prevalence was higher among early adolescent students (17.4%) compared with late adolescent students (14.7%), as reported by other authors within endemic areas (Risikat and Ayoade, 2012; Senghor *et al.*, 2014). The high prevalence may be due to more frequent water contact activities among early adolescents compared with young adults.

The majority (85.51%) of infected adolescents and young adults (secondary school students) had low-intensity infection. High-intensity infection was mainly found among students in Forms I and II, who are generally early adolescents; this may be due to their frequent engagement in recreational water practices, such as swimming. Similarly, other studies have reported that individuals aged <16 years are the main shedders of *S. haematobium* eggs in communities (Senghor *et al.*, 2014; Ojo *et al.*, 2021). Therefore, these results support recommendations from WHO to include other groups at risk in MDA control programmes, as these groups may represent reservoirs for transmission of urogenital schistosomiasis within communities (Faust *et al.*, 2020; World Health Organization, 2021).

The majority (94.2%) of secondary school students self-reported that they had taken praziquantel when they were at primary school. However, self-reported uptake of praziquantel was low, as the majority (80.4%) of students had participated in one or two rounds of MDA out of the seven rounds provided. This may be due, in part, to inadequate information about the importance of praziquantel in the past compared with the present time. Studies from Tanzania have reported fear of side effects of praziquantel, being sick, school absenteeism and lack of parental permission among the reasons for low uptake of praziquantel in primary school students (Yangaza *et al.*, 2022; Mushi and Tarimo, 2022; Mushi *et al.*, 2022a).

All participants had heard of urogenital schistosomiasis, and were aware that it is preventable, presumably because they had heard of the disease at primary school. Despite being aware of urogenital schistosomiasis, misconceptions regarding the modes of transmission were ob-

Table 9
Determinants of transmission of urogenital schistosomiasis among study participants (*n*=433).

Variable	Univariate analysis		Multivariate analysis	
	cOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value
Sex				
Male	1.12 (0.72–1.72)	0.618		
Female (Ref)	1			
Age group				
Early adolescents (13–15 years)	2.20 (0.84–5.80)	0.111	0.95(0.33–2.79)	0.930
Late adolescents (16–18 years)	2.33 (0.97–5.62)	0.005	1.44(0.57–3.66)	0.440
Young adults (19–21 years) (Ref)	1		1	
Form				
I	1.71 (0.88–3.33)	0.111	2.42 (1.16–5.04)	0.018[a]
II	1.47 (0.73–2.96)	0.278	1.64 (0.80–3.38)	0.179
III	1.47 (0.72–3.00)	0.291	1.61 (0.77–3.34)	0.203
IV (Ref)	1		1	
Ward of residency				
Sagata	1.89 (0.60–5.89)	0.274	2.44 (0.82–7.26)	0.110
Sasago	6.85 (2.54–18.49)	<0.001[a]	5.57 (1.98–15.67)	0.001[a]
Budalabujiga	3.09 (1.05–9.08)	0.040[a]	2.99 (1.04–8.56)	0.042[a]
Nkoma	2.27 (0.74–6.94)	0.151	2.81 (0.92–8.59)	0.070
Ndoleleji (Ref)	1	0.274	1	0.110
Classification of knowledge level				
Low	0.87 (0.42–1.78)	0.694		
Moderate	0.94 (0.73–4.07)	0.215		
High (Ref)	1	0.694		
Classification of attitude				
Positive	3.45 (1.43–8.33)	0.006[a]	3.14 (1.27–7.72)	0.013[a]
Negative (Ref)	1		**1**	
Ever used praziquantel				
Yes	0.24 (0.04–1.66)	0.148	0.28 (0.04–1.99)	0.206
No (Ref)	1	0.256	1	
Source of water used at home				
Pipes	0.99 (0.56–1.74)	0.958	0.72 (0.36–1.45)	0.360
River	2.10 (1.11–3.96)	0.023[a]	0.94 (0.41–2.20)	0.894
Lake and spring (Ref)	1		1	
Water body used for swimming				
Lake and spring	1.25 (0.53–2.97)	0.609	1.14 (0.46–2.83)	0.780
River	2.38 (1.29–4.40)	0.006[a]	1.92 (1.06–3.50)	0.032[a]
None (Ref)	1	0.609	1	
Urinating in water bodies				
Yes	2.90 (1.90–4.41)	<0.001[a]	1.68 (1.05–2.69)	0.032[a]
No (Ref)	1		1	
Farming				
Yes	1.97 (0.51–7.54)	0.325		
No (Ref)	1			
Fishing				
Yes	1.39 (0.90–2.14)	0.133	1.04 (0.69–1.56)	0.870
No (Ref)	1		1	

cOR, crude odds ratio; aOR, adjusted odds ratio; Ref, reference group.

served. The misconceptions observed could be associated with information gaps regarding certain aspects of urogenital schistosomiasis. In terms of prevention, only 9.7% of participants knew that the use of praziquantel is among the methods for prevention; this may have contributed to the low self-reported uptake of praziquantel in this group. A similar study in Ghana reported that secondary school students were more knowledgeable than primary school students. Being older, they have received health education on urogenital schistosomiasis for longer and more of them have participated in several rounds of MDA (Martel *et al.*, 2019). More than one-quarter (27.3%) of the participants had negative attitudes towards urogenital schistosomiasis. There is a high chance of this group engaging in risk behaviours which can perpetuate the transmission of urogenital schistosomiasis. This finding was similar to the results of a systematic review in sub-Saharan Africa (Sacolo *et al.*, 2018). Another study from Tanzania reported that low knowledge and negative attitudes towards urogenital schistosomiasis among adolescents aged 12–17 could affect prevention practices (Mushi et al., 2022b). As such, there is a need for communication programmes regarding social and behavioural changes to address negative attitudes and practices.

Inappropriate WaSH practices can influence the transmission and acquisition of urogenital schistosomiasis (Grimes *et al.*, 2014, 2015). The prevalence of *S. haematobium* was higher among adolescents and young adults who used a river as the water source at home, and were potentially exposed to cercariae while fetching water. Similarly, high prevalence of *S. haematobium* was observed among adolescents and young adults who practiced swimming in lakes, because lakes are likely to be infested with cercaria. Furthermore, the unhygienic practice of urination in water sources was significantly associated with high prevalence of *S. haematobium.* Urination in water sources, especially by infected individuals, results in contamination of the water source with viable eggs, and if Bulinus snails are present, this perpetuates the transmission of urogenital schistosomiasis. These findings are comparable with previous studies on the roles of WaSH in reducing schistosomiasis (Grimes et al., 2014, 2015).

The determinants of urogenital schistosomiasis among adolescents and young adults were being a student in Form I, being resident in Sasago ward or Budalabujiga ward, having positive attitudes, swimming in rivers, and urinating in water sources. The practices of swimming in rivers and urinating in water sources have been reported to be determinants/predictors of urogenital schistosomiasis in sub-Saharan Africa (Grimes et al., 2014, 2015). In Tanzania, Form I is the first class at secondary school after primary school. Students in Form I are still young and display risky practices acquired at primary school; as such, the odds of acquiring and transmitting urogenital schistosomiasis are higher among students in Form I compared with other forms (Forms II–IV). The risk of acquiring urogenital schistosomiasis was 5.57 and 2.29 higher for residents of Sasago ward and Budalabujiga ward, respectively, compared with residents of the remaining wards. This is similar to the findings of the national NTD control programme, which reported higher prevalence of urogenital schistosomiasis in Budalabujiga ward (26%) and Sasago ward (57.9%) compared with the remaining wards. The odds of transmission of urogenital schistosomiasis were three times higher for participants with positive attitudes compared with those with negative attitudes. It is possible for participants to be knowledgeable about urogenital schistosomiasis and have positive attitudes towards the disease but to practice risky behaviours due to environmental and socio-economic status. This finding is in contrast to the systematic review, which concluded that inadequate knowledge about the disease, negative attitudes and inappropriate practices were the determinants for transmission of urogenital schistosomiasis (Sacolo et al., 2018).

Study limitations

This study had a few limitations. Only a single urine sample was collected per participant, so it is possible that the prevalence of urogenital schistosomiasis may have been underestimated. Also, only macrohaematuria was detected (not microhaematuria), so morbidity may have been underestimated. Finally, some of the questions on self-reported history of praziquantel uptake required information recall, and were therefore subject to recall bias.

Conclusions and recommendations

The prevalence of urogenital schistosomiasis in adolescents and young adults was 15.9%, showing that this population is a reservoir for transmission of *S. haematobium* infection in Itilima district. Nearly two-thirds of adolescents and young adults had a high level of knowledge, and the majority had positive attitudes regarding the disease. The determinants for transmission of urogenital schistosomiasis were being a student in Form I, being resident in Sasago ward or Budalabujiga ward, having positive attitudes, swimming in rivers, and urinating in water sources. The new WHO NTD road map calls for inclusion of all population groups currently excluded from control programmes, and the epidemiological results of this study justify the extension of preventive chemotherapy to adolescents and young adults. Also, the Tanzanian Government should organize outreach programmes in Itilima district for regular screening and treatment of urogenital schistosomiasis. This will help in early detection of the disease, and management to prevent complications and morbidities. In addition, the Tanzanian Government should initiate health education programmes in secondary schools to eliminate risky practices and improve the water supply in the community. Finally, more studies should be conducted to determine epidemiological data among adolescents, both in school and out of school, in endemic areas.

Ethical approval

Ethical clearance was obtained from Muhimbili University of Health and Allied Sciences Institutional Review Board (MUHAS-REC-05-2021-615). Permission to conduct the study in Itilima district was sought from all administrative authorities, and permission for each school was requested from each ward executive officer and school head teacher. Before commencement of the study, consent was obtained after a thorough explanation of the study to the selected participants. Participants aged ≥18 years were asked to consent directly, while for participants aged <18 years, head teachers asked them to inform their parents and request permission to participate in this research. Parents who were willing for their children to participate in this study signed the consent form provided on their behalf. All children with urogenital schistosomiasis were referred to nearby health facilities with the assistance of the school health department team for appropriate treatment.

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Availability of data and materials

All relevant data are available within the paper.

Author contributions

LSM and DT conceptualized the study; LSM performed data collection; VM and LSM analysed the data, interpreted the findings, and drafted the manuscript; DT, GK and HM supervised the study and revised the manuscript. All authors read and approved the final version of the manuscript.

Declaration of Competing Interest

None declared.

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References

Angelo T, Kinung'hi SM, Buza J, Mwanga JR, Kariuki HC, Wilson S. Community knowledge, perceptions and water contact practices associated with transmission of urinary schistosomiasis in an endemic region: a qualitative cross-sectional study. BMC Public Health 2019;19:703.

Atalabi TE, Lawal U, Ipinlaye SJ. Prevalence and intensity of genito-urinary schistosomiasis and associated risk factors among junior high school students in two local government areas around Zobe Dam in Katsina State. Nigeria. Parasit Vectors 2016;9:388.

Cheesbrough M. District Laboratory Practice in Tropical Countries, Part 2 Second Edition. Cambridge University Press, 2006.

Clements AC, Brooker S, Nyandindi U, Fenwick A, Blair L. Bayesian spatial analysis of a national urinary schistosomiasis questionnaire to assist geographic targeting of schistosomiasis control in Tanzania, East Africa. Int J Parasitol 2008;38:401–15.

Creswell JW. Research design: qualitative, quantitative and mixed method approaches. Thousand Oaks, CA: Sage Publications; 2007.

Cribb DM, Clarke NE, Doi SAR. Vaz Nery S. Differential impact of mass and targeted praziquantel delivery on schistosomiasis control in school-aged children: a systematic review and meta-analysis. PLoS Negl Trop Dis 2019;13.

Faust CL, Osakunor DNM, Downs JA, Kayuni S, Stothard JR, Lamberton P, et al. Schistosomiasis control: leave no age group behind. Trends Parasitol 2020;36:582–91.

Folefac LN, Nde-Fon P, Verla VS, Tangye MN, Njunda AL, Luma HN. Knowledge, attitudes and practices regarding urinary schistosomiasis among adults in the Ekombe Bonji Health Area, Cameroon. Pan Afr Med J 2018;29:161.

Grimes JE, Croll D, Harrison WE, Utzinger J, Freeman MC, Templeton MR. The roles of water, sanitation and hygiene in reducing schistosomiasis: a review. Parasit Vectors 2015(8):156.

Grimes JE, Croll D, Harrison WE, Utzinger J, Freeman MC, Templeton MR. The relationship between water, sanitation and schistosomiasis: a systematic review and meta–analysis. PLoS Negl Trop Dis 2014;8:e3296.

Hotez PJ, Harrison W, Fenwick A, Bustinduy AL, Ducker C, Mbabazi PS, et al. Female genital schistosomiasis and HIV/AIDS: reversing the neglect of girls and women. PLoS Negl Trop Dis 2020;14.

Martel RA, Osei BG, Kulinkina AV, Naumova EN, Abdulai AA, Tybor D, et al. Assessment of urogenital schistosomiasis knowledge among primary and junior high school students in the Eastern Region of Ghana: a cross-sectional study. PLoS One 2019;14.

Mazigo H. Precision mapping of schistosomiasis and soil-transmitted helminthiasis and assessment of their associated risk factors at Itilima District, Simiyu region; 2020. North-Western Tanzania Mwanza. Research report

Mazigo HD, Nuwaha F, Kinung'hi SM, Morona D, Pinot de Moira A, Wilson S, et al. Epidemiology and control of human schistosomiasis in Tanzania. Parasit Vectors 2012;5:274.
Mushi V, Zacharia A, Shao M, Mubi M, Tarimo D. Persistence of *Schistosoma haematobium* transmission among school children and its implication for the control of urogenital schistosomiasis in Lindi, Tanzania. PLoS One 2022a;17.
Mushi V, Zacharia A, Shao M, Mubi M, Tarimo D. Prevalence and risk factors of urogenital schistosomiasis among under-fives in Mtama District in the Lindi region of Tanzania. PLoS Negl Trop Dis 2022b;16.
Mushi V, Tarimo D. Urogenital schistosomiasis knowledge, attitudes, and practices. East Afr Sci 2022;4:62–70.
National Bureau of Statistics. The United Republic of Tanzania 2012 population and housing census distributed by administrative areas. Ministry of Finance; 2013.
Neglected Tropical Disease Control Program in Tanzania. Report of 2016 on schistosomiasis control program among school age children. 2016, p. 23–5.
Ojo JA, Adedokun SA, Akindele AA, Olorunfemi AB, Otutu OA, Ojurongbe TA, et al. Prevalence of urogenital and intestinal schistosomiasis among school children in South-west Nigeria. PLoS Negl Trop Dis 2021;15.
PORALG-Itilima District Council. Available at: https://itilimadc.go.tz/(accessed 7 May 2022).
Richardson ST, Franklin AL, Rome ES, Simms-Cendan JS. Global health: urogenital schistosomiasis in the adolescent girl. J Pediatr Adolesc Gynecol 2016;29:326–32.
Risikat SA, Ayoade AA. Correlation analysis between the prevalence of schistosoma haematobuim and water conditions : a case study among the school pupils in South-western Nigeria. Int J Res Rev Appl Sci 2012;13:160–5.
Sacolo H, Chimbari M, Kalinda C. Knowledge, attitudes and practices on schistosomiasis in sub-Saharan Africa: a systematic review. BMC Infect Dis 2018;18:46.
Senghor B, Diallo A, Sylla SN, Doucouré S, Ndiath MO, Gaayeb L. Prevalence and intensity of urinary schistosomiasis among school children in the district of Niakhar, region of Fatick. Parasit Vectors 2014. doi:10.1186/1756-3305-7-5.
World Health Organization. Schistosomiasis. Geneva: WHO; 2019. Available at: https://www.who.int/news-room/fact-sheets/detail/schistosomiasis (accessed 23 April 2022).
World Health Organization. Prevention and control of schistosomiasis and soil-transmitted helminthiasis: report of a WHO expert committee. Geneva: WHO; 2002. Available at: (last accessed 13 July 2022) https://apps.who.int/iris/handle/10665/42588
. Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021–2030. Geneva: WHO; 2021. p. 6–9.
Yangaza Y, Mushi V, Zacharia A. Prevalence of urogenital schistosomiasis and risk factors for transmission among primary school children in an endemic urban area of Kinondoni municipality in Dar es Salaam. Tanzania. Microbes Infect Dis 2022. doi:10.21608/MID.2021.68520.1133.