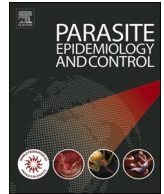




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Urogenital schistosomiasis prevalence, knowledge, practices and compliance to MDA among school-age children in an endemic district, southern East Tanzania

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ABSTRACT

Background: Tanzania has a high prevalence of urogenital schistosomiasis. Praziquantel is administered to school-age children on an annual basis as part of efforts to reduce transmission and morbidity associated with heavy infections. We investigated the prevalence, knowledge, and practices of urogenital schistosomiasis transmission, as well as compliance with mass drug administration (MDA) among schoolchildren in Masasi District.

Materials and methods: A cross-sectional survey was conducted in five primary schools. A pre-tested questionnaire was used to assess knowledge and practice related to the transmission of urogenital schistosomiasis, as well as compliance with MDA. Collected urine samples were examined macroscopically for macrohematuria. They were then tested for microhematuria and *Schistosoma haematobium* (*S. haematobium*) eggs with urine dipsticks and filtration technique, respectively.

Findings: The study included 389 primary school children in total. Overall, 27 (6.9%) of children had *S. haematobium* infection, and 37 (9.5%) had microhematuria. The mean (SD) intensity was 123.4 (247.4) eggs per 10 ml of urine. A total of 10 (2.6%) had heavy intensity of infection. The majority (94.9%) reported having complied to the previous round of MDA six months prior to this study, and 308 (79.2%) were aware that water contact is associated with an increased risk of urogenital schistosomiasis infection. Nevertheless, 182 (46.8%) of the participants engaged in swimming activities, with 92 (50.9%) of the participants being female. The prevalence of urogenital schistosomiasis was higher (10.9%) among children who participated in swimming activities versus those who did not (3.4%) ($P = 0.003$).

Conclusion: Despite high MDA compliance, urogenital schistosomiasis is still prevalent among primary school children in Masasi District. Children who swim in freshwater bodies such as rivers and ponds are more likely to contract urogenital schistosomiasis.

1. Introduction

Schistosomiasis affects nearly 240 million people worldwide. About 90% of the people at risk live in Sub-Saharan Africa (SSA) ([World Health Organization, 2021a](https://www.who.int/news-room/fact-sheets/detail/schistosomiasis)). The disease manifests itself in the gastrointestinal tract or the genital-urinary tract. *Schistosoma*

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haematobium (*S. haematobium*) causes urogenital schistosomiasis, which affects approximately 112 million people in SSA, 70 million of whom have hematuria (World Health Organization, 2020). Urogenital schistosomiasis is commonly characterized by hematuria (blood in the urine), bladder and ureter fibrosis, and kidney damage, which is sometimes diagnosed in advanced cases. In women, urogenital schistosomiasis can manifest as genital lesions or vaginal bleeding, a condition known as female genital schistosomiasis, which is caused by the presence of schistosome eggs and worms in the genital organs (World Health Organization, 2021a). People living in areas with poor sanitation, overcrowding, and low socioeconomic status are at a higher risk of infection (Ntonifor et al., 2015; Knopp et al., 2013; Dawaki et al., 2016; Bukindu et al., 2016). School-aged children have the highest prevalence and intensity of schistosomiasis infection (Hotez and Kamath, 2009).

Tanzania is ranked second to Nigeria for the countries with high prevalence of schistosomiasis in SSA (Mazigo et al., 2012), with a prevalence ranging from 12.7 to 87.6%. There is evidence of infection in all regions (Neglected Tropical Diseases Control Program, 2015). Urogenital schistosomiasis is highly endemic along the coastal belt of Tanzania (Brooker et al., 2009). Human exposure to urogenital schistosomiasis is primarily related to occupational activities such as fishing, farming, or recreational activities in the basin or within permanent or temporary freshwater bodies such as lakes, rivers, dams, swampy areas, or roadside ditches (Manz et al., 2020; Ndyomugenyi and Minjas, 2001).

The National Schistosomiasis and Soil-Transmitted Helminth Control Program was established in 2004 to support schistosomiasis control initiatives by administering praziquantel and albendazole via mass drug administration (MDA) to primary school-age children (Bukindu et al., 2016; Mazigo et al., 2010). MDA aims to reduce transmission and control morbidity associated with heavy infections (Bukindu et al., 2016). However, insufficient use of preventive measures among school-age children has been reported (Munisi et al., 2017). Moreover, because chemotherapy does not prevent subsequent infection, re-infection is possible if water contact is maintained (Chaula and Tarimo, 2014). A lack of knowledge about disease transmission and preventive measures also has an influence on disease transmission (Munisi et al., 2017; Person et al., 2016; Donohue et al., 2017).

Masasi district is endemic for *S. haematobium*. For more than a decade, the district has been implementing a school-based deworming campaign. However, there is little data on the current state of urogenital schistosomiasis transmission among school-aged children. We assessed the prevalence, knowledge, and practices related to urogenital schistosomiasis transmission, as well as

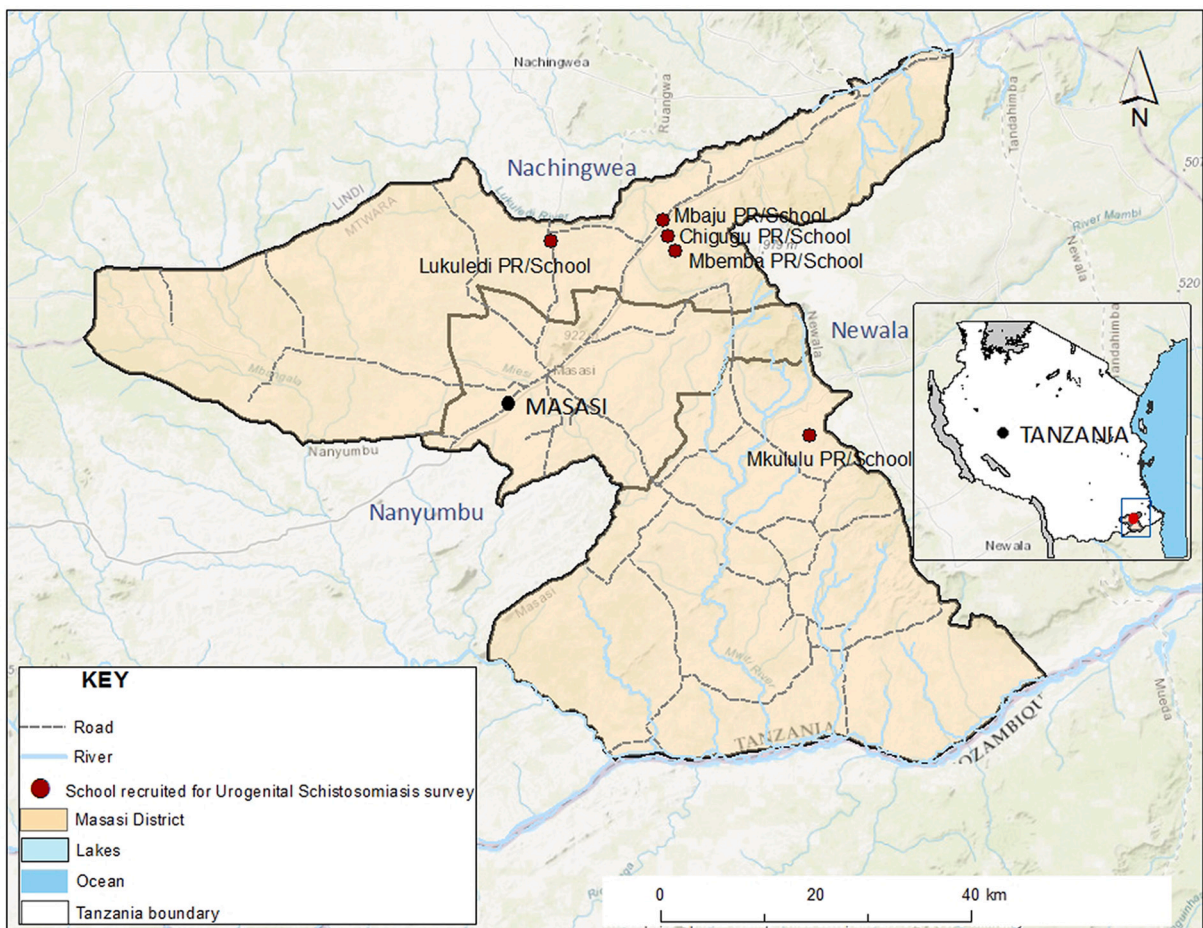


Fig. 1. A map showing the location of Masasi district and the schools recruited for Urogenital schistosomiasis survey (Credit: Alex. J. Limwagu).

compliance with MDA, among school-aged children in the District.

2. Materials and methods

2.1. Study area

The study was carried out in Masasi District, (10.7348°S, 38.8044° E) southern-east Tanzania. The district is bordered to the south by the Ruvuma River, which serves as a fishing site. According to the National Population Census 2012, the district has a total population of 260,856 people (National Bureau of Statistics, 2012). The average temperature in the area is 25.4 °C, and the average annual rainfall is 1024 mm, with 82% humidity (Weather Atlas, n.d.). The residents primarily engage in cashew nut farming and fishing (Masasi District profile, 2021). Schistosomiasis and soil-transmitted helminths control campaigns began in 2004 with annual MDA of praziquantel and albendazole to school-aged children.

2.2. Study design and study population

A cross-sectional study was carried out in five selected primary schools: Mbaju, Chigugu, Mbemba in Chigugu ward, Lukuledi and Mkululu in Lukuledi and Mkululu wards (Fig. 1). The study population consisted of primary school students in grades one through six who attended the selected schools during the study period.

2.3. Eligibility criteria

The study included children aged 6–15 years, present during the data collection day and whose parents provided written informed consent for participation in the study. The study excluded children with a history of using anti-schistosome drugs (praziquantel) for 14 days prior to or at the time of the study.

2.4. Sample size and sampling

Pourhoseingholi's sample size estimation method was used (Pourhoseingholi et al., 2013). Based on a recent study in Lindi, the input parameters included an estimated 49% proportion of urogenital schistosomiasis (Bakuza, 2018). We also used a 95% level of confidence and a 5% absolute precision; we also adjusted for a 10% non-response rate.

A two-stage sampling technique was used. First, five primary schools were chosen from a list of 60 public schools in Masasi district council using a cluster sampling technique. To obtain the desired number of children per school, the calculated sample size of 422 was divided by five schools. The number obtained for each school was then divided by six to obtain the sample of children from class one to class six. Then, using a simple random sampling technique, we recruited the required number of children for each class. Briefly, eligible students were mobilized, informed about the study, and instructed to select one folded paper labeled "Included" or "Not Included." Those who chose a folded piece of paper with the word "Included" on it were recruited.

2.5. Data collection

2.5.1. Questionnaire survey

A pre-tested structured questionnaire was used to collect demographic information from participants, such as age and gender. The class registers were used to determine the age of each child who took part in the study. The knowledge of urogenital schistosomiasis transmission was assessed. We also asked questions about toilet use, hand washing, shoe-wearing habits, swimming, and water contact behavior. Participation and drug uptake during the previous round of MDA, six months prior to data collection, were also evaluated. Those who did not participate/swallow the tablets were asked to explain why.

2.5.2. Urine sample collection

Each participant provided a urine sample in a clean, transparent, 50 ml dry wide-mouthed, labeled plastic container, as previously described (Ngasala et al., 2020). The urine samples were collected between 10:00 a.m. and 2:00 p.m., which is the best time for egg passage. On-site visual examinations were performed on each sample to screen for macrohematuria. Urine chemical reagent strips were also used to screen urine samples for microhematuria (Urine 10 parameters, Neotest Multistix, United Kingdom). To test for occult blood, a strip was dipped into the urine container for five seconds. To estimate the amount of blood in the urine, the color change of the strip was compared to a color chart on a strip container. According to the manufacturer's recommendations, we recorded the results as negative or positive. For the preservation of *Schistosoma* eggs, two to four drops of 10% formaldehyde were added to each sample. The samples were then transferred to the parasitology laboratory at Muhimbili University of Health and Allied Sciences for parasitological examination.

2.5.3. Examination for *Schistosoma haematobium* eggs

Parasitological examination was carried out in the laboratory using the urine filtration technique. Urine samples were gently shaken before being drawn into a syringe and discharged through a nucleopore filter membrane as previously described (Ngasala et al., 2020). An experienced laboratory technologist placed a nucleopore filter membrane on the slide, stained it with Lugol's iodine, and

examined it under a microscope. The number of eggs per 10 ml of urine was used to determine the intensity of the infection. To differentiate between light and heavy intensity, a threshold of 50 eggs was used (World Health Organization, 2021b).

2.6. Data analysis

The Statistical Package for Social Sciences software version 20.0 (IBM Corp., Armonk, NY, USA) was used to enter and analyze data. To estimate the overall prevalence of urogenital schistosomiasis, descriptive statistics were calculated and stratified by sex, age group, class, and school. To compare the prevalence between groups, the chi-square test was used (95% confidence interval (CI) and a P -value $<0.05\%$ considered significant). Urine filtration (microscopy) was used as the gold standard technique to determine the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the indirect diagnostic method (microhematuria).

2.7. Ethical consideration

The ethical approval was obtained from the Muhimbili University of Health and Allied Sciences Institution Review Board (IRB Ref. No.DA.287/298/01A/). The District Executive Director (DED) granted permission to conduct the study in selected schools through the District Education Officer and the head teacher of the respective school. Finally, the parents or guardians of the selected children provided written informed consent. Participation was entirely voluntary; parents/guardians had the option of accepting or declining their children's participation in the study. Furthermore, children provided verbal assent to ensure that their participation was voluntary. If a parent or guardian refused, the child's name was removed from the list of participants. Children with urinary schistosomiasis were referred to a nearby medical facility for treatment.

3. Results

3.1. Demographic characteristics of the study participants

A total of 389 of the 422 children chosen for the study met the inclusion criteria. The average age was 10.1 ± 2.1 years, and 169 (43.5%) were between the ages of 10 and 12 years. More than half of the participants, 210 (54%) were female (Table 1).

3.2. Prevalence and intensity of urogenital schistosomiasis

The urine filtration method detected *S. haematobium* infection in 27 (6.9%) of the 389 participants. Male and female infection rates were 8.9% and 5.2%, respectively ($P = 0.166$). Children attending Chigugu primary school had a significantly higher prevalence of *S. haematobium* infection, 17.9%, while children attending Mbemba primary school had the lowest prevalence, 2.6% ($P = 0.001$) (Table 2).

The mean (SD) infection intensity (eggs per 10 ml of urine) was 123.4 (247.4). About 10/27 (37.1%) of *S. haematobium* infected children had high intensity, equivalent to 2.6% of all participants. Children attending Chigugu primary school had higher mean infection intensity (196.2 eggs per 10 ml of urine), whereas children attending Mbemba primary school had the lowest mean infection intensity (2 eggs per 10 ml of urine). Males had a lower mean egg count (188.6 eggs per 10 ml of urine) than females (78.6 eggs per 10 ml). Likewise, children aged 10 to 12 years had a higher mean egg count (190.5 eggs per 10 ml) ($P > 0.05$) (Table 3). There was no statistically significant difference in the prevalence or intensity of urogenital schistosomiasis by gender or age group.

Table 1
Demographic characteristics of study participants.

Variable	Category	Frequency	Percentage (95%CI)
Sex	Male	179	46.0 (40.6–50.9)
	Female	210	54.0 (49.1–59.4)
Age group	6–9 years	165	42.4 (37.3–47.3)
	10–12 years	169	43.5 (38.6–48.6)
	13–15 years	55	14.1 (10.8–18.0)
School	Mbaju	78	20.1 (15.9–23.7)
	Chigugu	78	20.1 (16.5–24.2)
	Mbemba	77	19.8 (15.9–24.2)
	Lukuledi	78	20.1 (16.2–23.9)
	Mkululu	78	20.1 (16.2–24.2)
Class	I	65	16.7 (12.9–20.3)
	II	64	16.5 (12.6–20.1)
	III	65	16.7 (13.1–20.6)
	IV	65	16.7 (13.1–20.6)
	V	65	16.7 (13.1–20.6)
	VI	65	16.7 (13.1–20.8)

Table 2
Prevalence of Urogenital schistosomiasis by filtration and indirect diagnostic methods.

Variable	Category	Macrohematuria		Microhematuria		Filtration	
		Positive (%)	p-value	Positive (%)	p-value	Positive (%)	P-value
Overall (n = 389)		5(1.3)		37 (9.5)		27 (6.9)	
Sex	Male	2 (1.1)	1.000*	20 (11.2)	0.302	16 (8.9)	0.166
	Female	3 (1.4)		17 (8.1)		11 (5.2)	
Age group (years)	6–9	2 (1.2)	1.000*	10 (6.1)	0.130	11 (6.7)	0.794
	10–12	3 (1.8)		21 (12.4)		11 (6.5)	
	13–15	0 (0.0)		6 (10.9)		5 (9.1)	
School class	Mbaju	0 (0.0)	0.207*	9 (11.5)	0.000	4 (5.1)	0.001
	Chigugu	1 (1.3)		18 (23.1)		14 (17.9)	
	Mbemba	1 (1.3)		4 (5.2)		2 (2.6)	
	Lukuledi	0 (0.0)		2 (2.6)		4 (5.1)	
	Mkululu	3 (3.8)		4 (5.1)		3 (3.8)	
	I	1 (1.5)	0.905*	4 (6.2)	0.064	5 (7.7)	0.862*
II	0 (0.0)		3 (4.7)		4 (6.2)		
III	1 (1.5)		4 (6.2)		3 (4.6)		
IV	2 (3.1)		10 (15.4)		4 (6.2)		
V	0(0.0)		11 (16.9)		7 (10.8)		
VI	1 (1.5)		5 (7.7)		4 (6.2)		

3.3. Diagnostic accuracy of urogenital schistosomiasis using urine dipstick screening method

Macrohematuria and microhematuria were found in 1.3% and 9.5% of participants, respectively. The prevalence of microhematuria varied significantly between schools ($P = 0.0001$) (23.1% in Chigugu vs. 2.6% in Lukuledi). Children aged 10–12 years had a higher prevalence of microhematuria (12.4%) ($P = 0.13$) (Table 2). There were no significant differences in the prevalence of microhematuria by age, gender, or class ($P > 0.05$). The Fisher exact test revealed an association between the prevalence of urogenital schistosomiasis and microhematuria. The urine reagent strips had a high sensitivity (92.6%) and specificity (96.7%). The NPV and PPV were also high, at 99.4% and 67.6%, respectively (Table 4).

3.4. Knowledge on transmission of urogenital schistosomiasis transmission among primary school children

Overall, 308 people (79.2%) agreed that water contact behaviors like swimming, bathing, and washing clothes in lakes or rivers are linked to urogenital schistosomiasis infection. The majority of participants (324, or 83.3%) agreed that urinating in freshwater bodies causes urogenital schistosomiasis transmission. Walking barefoot is associated with urogenital schistosomiasis infection, according to 298 (76.6%) participants. Also, 299 (76.9%) of the children reported that urogenital schistosomiasis is associated with eating without washing hands. However, knowledge of transmission was not associated with urogenital schistosomiasis infection ($P > 0.05$).

3.5. Practices related to transmission of urogenital schistosomiasis among primary school children

Overall, 182 (46.8%) of the participants engaged in swimming activities, with 92 (50.9%) of the participants being female. In addition, 201 (51.7%) had a history of water contact, such as bathing or washing clothes in rivers or ponds. About 386 (99.2%) used

Table 3
Intensity of *S. haematobium* infection presented by sex, age group, school and class.

Variable	Category	No. of positive cases	Mean (SD) eggs/10 ml	Light, n (%)	Heavy, n (%)	p-value
Overall	–	27	123.4 (247.4)	17 (62.9)	10 (37.1)	0.988
Sex	Male	16	78.6 (117.7)	10 (62.5)	6 (37.5)	1.000*
	Female	11	188.6 (361.1)	7 (63.6)	4 (36.4)	
Age group in years	6–9	11	90.6 (130.8)	6 (54.5)	5 (45.5)	0.871*
	10–12	11	190.5 (360.1)	7 (63.6)	4 (36.4)	
	13–15	5	47.8 (91.3)	4 (80.0)	1 (20.0)	
School	Mbaju	4	60.5 (100.7)	3 (75.0)	1 (25.0)	0.238*
	Chigugu	14	196.2 (324.2)	7 (50.0)	7 (50.0)	
	Mbemba	2	2.0 (1.4)	2 (100.0)	0 (0.0)	
	Lukuledi	4	10.8 (11.4)	4 (100.0)	0 (0.0)	
	Mkululu	3	98.3 (102.7)	1 (33.3)	2 (66.7)	
Class	I	5	141.0 (171.7)	2 (40.0)	3 (60.0)	0.041*
	II	4	7.5 (9.2)	4 (100.0)	0 (0.0)	
	III	3	136.7 (68.7)	0 (0.0)	3 (100.0)	
	IV	4	292.8 (505.9)	2 (50.0)	2 (50.0)	
	V	7	141.0 (279.3)	5 (71.4)	2 (29.6)	
	VI	4	7.0 (4.5)	4 (100.0)	0 (0.0)	

Table 4
Diagnostic accuracy of urogenital schistosomiasis using urine dipstick screening method.

Urine dipstick	Urine filtration		Total
	Egg(s) present	Egg(s) absent	
Positive	25	12	37
Negative	2	350	352
Total	27	362	389

(Fisher exact test, $P = 0.000$)

the toilets while at school; 315 (80.9%) washed their hands after using the toilet; and 374 (96.1%) washed their hands before eating. A minority (15.4%) of children reported urinating in water, and 136 (34%) wore shoes only to school. Infection rates were higher (10.9%) among children who participated in swimming activities compared to 3.4% among those who did not ($P = 0.003$) (Table 5). In addition, the proportion of infected children who participated in swimming activities was higher; 12 (13.3%) in boys compared to 8 (8.7%) in girls. Similarly, children with water contact behavior had a higher infection rate (8.9%) than children with no reported water contact history (4.8%) ($P = 0.01$) (Table 5).

3.6. Compliance to MDA among school children

According to self-reported data, 369 (94.9%) of schoolchildren participated in the previous round of MDA by receiving the tablets; only four (1.1%) did not swallow the provided tablets. The prevalence of infection was 15% among children who did not participate in MDA vs. 6.5% among those who did ($P > 0.05$) (Table 6). The main reasons for not participating were being absent during MDA, 11 (57.9%), and parental restrictions, 7 (35%) (See Fig. 2).

4. Discussion

The current study found a low prevalence of *S. haematobium* infection using the urine filtration method, indicating a low transmission of urogenital schistosomiasis infection among primary school children (World Health Organization, 2010). More than half of the infected children had a light intensity of infection (<50 eggs count per 10 ml of urine). This could be attributed to the praziquantel MDA six months prior to this study. Furthermore, the low (<5%) prevalence of high heavy intensity of infection indicates that

Table 5
Knowledge and practice for urogenital schistosomiasis transmission among primary school children.

Question	Options	Response	No. (%) of responses	Schistosomiasis infection		P - value
				Positive	Negative	
Do the following could results to urogenital schistosomiasis transmission?	Walking with bare foot	Yes	298 (76.6)	22 (7.4)	276	0.535
		No	91 (23.4)	5 (5.5)	86	
	Urinating outdoor	Yes	298 (76.6)	21 (7.0)	277	0.555
		No	91 (23.4)	6 (6.6)	85	
	Eating without hand washing	Yes	299 (76.9)	22 (7.3)	277	0.535
		No	90 (23)	5 (5.6)	85	
	Not washing hands after toilet	Yes	298 (76.6)	22 (7.4)	276	0.555
		No	91 (23.4)	5 (5.5)	86	
	Urinating in water	Yes	324 (83.3)	22 (6.8)	302	0.790
		No	65 (16.7)	5 (7.7)	60	
	Contact with river and pond water (swimming, bathing and washing clothes)	Yes	308 (79.2)	21 (6.8)	287	0.853
		No	83 (21.3)	8 (1)	75	
Do you practice the following?	Urinate in toilet when at school	Yes	386 (99.2)	27 (6.9)	359	1.000*
		No	3(0.8)	0 (0.0)	3	
	Wash hands after toilet	Yes	315(80.9)	22 (6.9)	293	0.945
		No	74 (19.1)	5 (6.8)	69	
	Wash hands before eating	Yes	374(96.1)	27 (7.2)	347	0.612*
		No	15(3.9)	0 (0.0)	15	
	Swimming	Yes	182(46.8)	20 (10.9)	162	0.003
		No	207(53.2)	7 (3.4)	200	
	Bath/wash clothes in river/pond	Yes	201(51.7)	18 (8.9)	183	0.105
		No	188(48.3)	9 (4.8)	179	
	Urinate in water	Yes	60(15.4)	3 (5)	57	0.782*
		No	329(84.6)	24 (7.3)	305	
How often do you wear shoes	All the time	253(65)	19 (7.5)	234	0.547	
	At school	136 (34.9)	8 (5.9)	128		

Table 6
Compliance to MDA among school age children and schistosomiasis infection.

Question	Response	No. (%)	Schistosomiasis infection		p - value
			Positive (%)	Negative (%)	
Did you take part in the last school MDA? (n = 389)	Yes	369 (94.9)	24 (6.5)	345 (93.5)	> 0.05*
	No	20 (5.1)	3 (15.0)	17 (85.0)	
Did you swallow the praziquantel tablet(s) (n = 369)	Yes	365(98.9)	24 (6.6)	341 (93.4)	> 0.05*
	No	4 (1.1)	0 (0.0)	4 (100.0)	

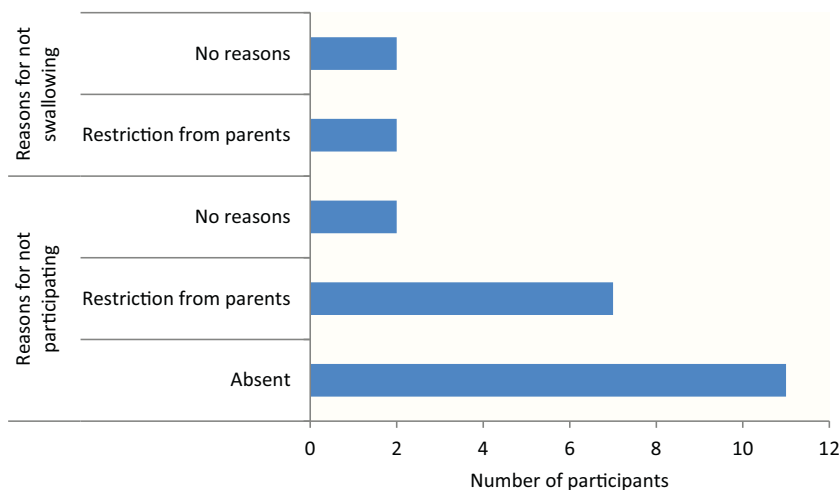


Fig. 2. The reasons for not participating during MDA campaigns ($n = 12$) and the reasons for not swallowing the tablets during MDA ($n = 4$).

morbidity has been controlled (World Health Organization, 2010). The proportion of children with heavy intensity of infection was nearly three times higher than the <1% target for the elimination of schistosomiasis as a public health concern (World Health Organization, 2021b; World Health Organization, 2010). So, while the interventions have clearly controlled morbidity, they have yet to eliminate urogenital schistosomiasis as a public health problem.

Compliance with praziquantel and albendazole MDA was higher, surpassing the World Health Organization's (WHO) recommended minimum coverage of 75% (World Health Organization, 2010). Similarly, the majority of the children were aware of the risk factors for urogenital schistosomiasis transmission. However, nearly half of the children participated in swimming activities, and more than half had a history of water contact, such as washing clothes and utensils and fetching water from the river. Despite ongoing MDA, these findings show that urogenital schistosomiasis is still being transmitted in the district. It also suggests that re-infection could occur shortly after MDA.

The prevalence reported in this study is comparable to that reported in a recent study of schoolchildren in the Mtera Dam area (Ngasala et al., 2020). Both microhematuria and *S. haematobium* infection are slightly higher than in a recent study conducted in Pemba, Zanzibar (Knopp et al., 2016). This demonstrates that urogenital schistosomiasis is still prevalent in both mainland and island Tanzania. Nonetheless, the low prevalence of urogenital schistosomiasis reported in the cities of Dar es Salaam and Tanga after a decade of MDA (Mwakitalu et al., 2014) indicates heterogeneity in transmission between urban and rural settings, which is clearly linked to access to safe water.

Children at Chigugu primary school had a significantly higher prevalence of *S. haematobium* infection, as well as the most severe infection. According to the researchers' observations, children in this school did not have access to safe water (tap/well) near their compounds, so they relied on river water for their daily utilities, which may expose children to contaminated water, increasing their risk of infection. Similarly, the higher prevalence of *S. haematobium* among children aged 13–15 years and in class V could be attributed to water contact behaviors such as swimming. Furthermore, females had a higher mean intensity of *S. haematobium* infection than males, which could be attributed to gender roles of girls and women, such as washing clothes and fetching water for domestic purposes, which expose them to infection. However, findings from studies in Ethiopia and Senegal (Geleta et al., 2015; Senghor et al., 2014) show that males have a higher mean intensity of *S. haematobium* infection than females. These variations could be attributed to environmental factors and culture (Degarege et al., 2015).

The majority of the children were aware that bathing, swimming, washing, and playing in infested water sources can spread urinary schistosomiasis. This, however, was not associated with urogenital schistosomiasis infection in this study. Swimming in rivers or playing in water was, however, a common practice among the children; this was also a commonly reported practice in previous studies (Geleta et al., 2015; Pennance et al., 2016; Frigerio et al., 2016; Maseko et al., 2018). The proportion of swimming practices by girls

and boys was nearly equal. However, higher prevalence of *S. haematobium* infection was recorded among boys that engage in swimming than girls. This suggests that boys are more susceptible to infection than girls.

Indeed, children who swam had a significantly higher prevalence of urogenital schistosomiasis than those who did not. It is certain that the continued transmission is due to continued water contact, despite the repeated rounds of MDA. Several previous studies have confirmed these findings (Geleta et al., 2015; Frigerio et al., 2016). Furthermore, urinating in open water was reported frequently among adults in Cameroon and by a minority of children in Swaziland (Maseko et al., 2018; Folefac et al., 2018). A qualitative study conducted in Zanzibar discovered that children engage in high-risk behaviors for contracting schistosomiasis due to a lack of knowledge about disease transmission (Person et al., 2016). In addition to the ongoing MDA intervention, mass education campaigns aimed at both adults and children are required.

The findings also show that MDA compliance is high among primary school children. Though self-reporting on compliance may have resulted in recall bias, non-compliance was certainly associated with a higher prevalence of infection, as previous studies have shown (Chaula and Tarimo, 2014; Knopp et al., 2016). Reasons given by students who did not participate in/swallow the tablets during MDA included parental restrictions, being absent from school on the day of MDA, and fear of the side effects. Pre-MDA education and communication with both parents and children may help to dispel these myths.

5. Conclusion

Despite a decade of MDA with praziquantel and albendazole and high compliance among the children, urogenital schistosomiasis remains prevalent among school children in Masasi district. The continued transmission of urogenital schistosomiasis among schoolchildren could be attributed to their continued water contact behavior. In addition to MDA, improving access to safe and clean water and behavioral change interventions may help to reduce urogenital schistosomiasis transmission in the district.

Authors' contributions

LN: Conceptualization, Data curation, Investigation, Methodology and Writing-original draft
 EL: Conceptualization, Writing-original draft and Editing
 AZ: Methodology, Data curation, Formal Analysis, Visualization, Writing -review and Editing
 BN: Conceptualization, Supervision and Writing -review

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Declaration of Competing Interest

The authors declare that they have no competing interests.

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