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Prevalence and risk factors associated with *Schistosoma haematobium* infection among school pupils in an area receiving annual mass drug administration with praziquantel: a case study of Morogoro municipality, Tanzania

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Abstract

Background: There is a scarcity of accurate data on *Schistosoma haematobium* infection on country-specific prevalence despite mass drug administration over the years. Prevalence estimates for the number of people infected and the number at risk of infection must still be made based on calculations of limited prevalence survey data at the country level. This study aimed to fill in the gap of data on prevalence in an urban setting that has been receiving mass drug administration with praziquantel and determine the risk factors associated with *S. haematobium* infection among school pupils.

Method: A cross-sectional, stage-wise random sampling survey of *S. haematobium* infection, factors influencing its transmission and mass drug administration with praziquantel were studied among primary school pupils in Morogoro Municipality. A semi-structured questionnaire was used to collect data on risk factors, and urine samples were collected from pupils and examined for *S. haematobium* eggs and macro and microhematuria. Results were analyzed using SPSS version 12.0.

Result: The overall prevalence rate of *S. haematobium* infection was found to be 32.5% (95% CI, -3.1- 5.6%) in the ten schools that were sampled. It was observed that 228/884 (25.8%) of the pupils had low infection intensity and 82/884 (9.3%) had high infection intensity. The total number of pupils that had *S. haematobium* infection was 287, where 116 (40.42%) of them had micro-hematuria. The proportion of students that did receive praziquantel in the last general distribution was found to be 14.3% while 25.8% of the students had low infection intensity and 9.3% had high infection intensity across all age groups. Whereby 3.96% of pupils that received praziquantel in the last general administration also had *S. haematobium* infection (OR 0.77, 95% CI 0.5-1.2) The risk factors associated with *S. haematobium* infection were playing, bathing, fishing in rivers and helping parents work in rice fields (p –value<0.001).

Conclusion: The prevalence and intensity are high enough to cause re-infection. Still, more effort is needed to enforce mass praziquantel administration among primary school pupils, alternative water sources for recreational activities, provision of proper latrines and further studies needed to explore the risk factors.

Keywords: *Schistosoma haematobium*, mass-drug administration, urinary schistosomiasis, primary school children

Introduction

Schistosomiasis remains one of the most prevalent parasitic infections in the world, whereby, as of 2021 estimates showed that at least 251.4 million people required preventive treatment (WHO, 2020). *Schistosoma haematobium* causing urogenital schistosomiasis is among the water-borne neglected tropical diseases associated with significant morbidity and mortality in tropical and subtropical areas (Grimes et al., 2014).

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People are infected when schistosomes are transmitted during contact with fresh water contaminated with human excreta containing parasite eggs. A snail host must be present in the water to allow the parasite to complete its life cycle. It is particularly linked to agricultural and water development schemes. Groups at risk for schistosomiasis are preschool-aged children (pre-SAC), school-aged children (SAC), adults in certain occupational groups, women who are in contact with infected water for domestic activities and entire communities in high-risk areas (WHO, 2020). Preventive treatment is required to be repeated over several years, to reduce and prevent morbidity. However, preventive chemotherapy for schistosomiasis, where people and communities are targeted for large-scale treatment, is only required in 51 endemic countries with moderate-to-high transmission (Engels et al., 2002; WHO, 2020).

In Tanzania, schistosomiasis prevalence is estimated at 51.5% whereby, approximately 23.2 million people were estimated to have schistosomiasis in 2011 (Mazigo et al., 2012) however, no recent country prevalence has been estimated. Urogenital schistosomiasis is endemic at varying transmission levels in all administrative regions and districts in the country (Mazigo et al., 2012). *S. haematobium* worms' dwell within the veins draining the main pelvic organs, including the bladder, uterus, cervix and rarely in the gastrointestinal organs (Santos et al., 2021). In the infectious stage of the parasite, larvae cercariae that emerge from freshwater snails infect humans through direct skin penetration. The worms migrate into the circulation, mature and lodge within the venous plexus of the bladder, where they reproduce, and females release eggs. The released eggs provoke granulomatous inflammation and the primary organ affected is the ureter (Warren et al., 1967).

The developed lesions lead to the formation of sandy patches, ulcerations and polypoid lesions in the bladder and ureters, resulting in hematuria, obstructions of urine flow, calcified bladder wall and cancer (Hatz et al., 1998; King, 2001; Santos et al., 2021). Common early signs include dysuria, proteinuria, and hematuria (Hatz et al., 1998; King, 2001). Epidemiological and clinical studies conducted in part of Tanzania mainland (McMahon, 1967; Poggensee et al., 2000; Sarda et al., 1985; Scheich et al., 2012; Zumstein, 1983) and the islands of Zanzibar (Forsyth & MacDonald, 1965, 1966; G. Macdonald & Forsyth, 1968; M. Macdonald, 1968; Rudge et al., 2008; Stothard et al., 2002), have reported high prevalence of *S. haematobium* and different types of morbidities associated with urogenital schistosomiasis across all age groups and gender.

Mass drug administration (MDA) targeting SAC within the school environment campaigns were initiated in numerous endemic areas, Tanzania included (World Health Organization, 2013). There is indeed evidence that the impact of treatment on morbidity decreases with age and that repeated treatment in the early stages of life has a long-lasting effect on morbidity at a later by preventing chronic sequel in adulthood (Engels et al., 2002). Parasitological data are used to determine the eligibility of an area for MDA based on the endemicity level (Sturrock et al., 2009; WHO, 2006). Although the intensity of schistosome infection has greater relevance to transmission dynamics and morbidity (Dye, 1991), the prevalence of infection, based on microscopic examination of schistosome eggs in stool or urine samples, remains the most widely used indicator of infection status and is employed by WHO in making recommendations for control (Clements et al., 2006). However, mapping using parasitological data on SAC and primary school children is still very limited and despite years of MDA in the country, there is limited information on post-MDA geographical prevalence for many of the endemic districts (Ministry of Health Tanzania, 2010).

Over the years, Morogoro region has been implementing MDA with Praziquantel (PZQ) to primary school pupils (PSPs) as the main intervention for the control of schistosomiasis (Ministry of Health Tanzania, 2010). Yet prevalence and intensity of urinary schistosomiasis in Morogoro municipality are not available and no post-MDA prevalence has been assessed. The risk factors associated with schistosomiasis transmission; potentially infected water with cercariae and inadequate sanitation and hygienic practices continue to supplement the circle of re-infection and no studies have been carried out to reassess their role in transmission. There is a gap in the area of linking MDA with praziquantel, post-MDA prevalence and associated risk factors among SAC in an area of urban setting. Data from urban settings is needed to aid in the implementation and evaluation of interventions control of *S. haematobium* infections causing urogenital schistosomiasis. The current study aimed to address this gap and determine the prevalence and intensity of urinary schistosomiasis and the factors associated with its transmission.

Method

Study area

The study was conducted in Morogoro municipality within the Morogoro Urban District. Morogoro Urban District is one of the six districts of the Morogoro Region of Tanzania. Morogoro Municipality has of population of 471,407 people and has a variety of water sources including, shallow wells, constructed or improved traditional pipe water systems, streams and rivers, dams, and bore holes (National Bureau of Statistics, 2020). Mass drug administration with praziquantel and albendazole to SAC is implemented in Morogoro municipal (Neglected Tropical Diseases Program Tanzania, 2023).

Study design

This was a cross-sectional study in which a semi-structured questionnaire was used to generate information on visible hematuria, water contact patterns, hygiene or sanitary practices and MDA with praziquantel. The target of the study population was primary school pupils of all age groups from the public primary schools in the Morogoro municipality.

Sample size estimation

Ten out of fifty-six primary schools were multistage random sampled in which a minimal number of 778 was required to be sampled. A total of 884 students ended up being sampled.

The minimum sample size was obtained using the following formula:

$$n = (1.96/ w) 2 p (1-p)$$

Where: n = sample size (minimum sample size)

W = margin of error on P (3%) = 0.03

p = the highest prevalence of *S. haematobium* that had been found to infect primary school children in the study area (86%) = 0.86.

Therefore; n = (1.96/0.03) 2 0.86(1-0.86) = 512

This was a stage-wise random sampling, therefore calculated variance inflation factor (f) is 1.5: 514(f) = 514 * 1.5 = 768, when added 10% for missing data, dropout or non-response the sample size was 845.

The minimum calculated sample for this study was 845 primary school pupils. We interviewed 884 pupils from ten schools.

Sampling procedure

Two-stage random sampling was used to select participants who were interviewed using a semi-structured questionnaire. During sampling, a sampling frame of all public primary schools located in the municipality was obtained from the Municipal Education Officer. Using a list of all public primary schools in the Municipality, the name of each of the primary schools in the municipality was written on a separate piece of paper and then assembled in one box for sampling. A simple random sampling was applied by picking ten pieces of paper with the names of ten primary schools. After selecting the schools, the names of pupils were obtained from the daily attendance book by random sampling. All identified pupils from the daily attendance and who agreed to participate were included in the study. Pupils who were identified and agreed to participate but were absent at the time of the study were excluded. The refusal to participate was respected and replaced by other pupils from daily attendance who agreed to participate.

Data collection

A semi-structured questionnaire was used to generate data from the pupils. Immediately after interviewing the pupils, the next step was to collect urine specimens in which screwed plastic containers marked with an identification number were provided to each of the sampled pupils to collect a fresh urine sample. Pupils were instructed to collect about 10 millilitres of fresh urine specimens respectively. The pupils received thorough instructions on how to collect a sufficient amount of urine. Urine samples were collected between 10.00 a.m. and 2.00 p.m., a convenient time for high egg output. Ten pupils at a time were allowed at once to go for urine sample collection to make sure that they did not find an opportunity to share their urine samples. The collected urine sample was mixed with 2 milliliters of 10% formaldehyde to prevent bacteria growth and eggs hatching then were placed in a cold box immediately after collection. The samples were taken to the laboratory for examination on the same day. In brief, 10 ml from each sample of urine was passed through a millipore filter (12 µm polycarbonate filter), and the filter then was placed on a glass slide for quantitative examination of *S. haematobium* eggs under a light microscope (x40 objective lens). Those found with one or more eggs were recorded as infected and the number of *S. haematobium* eggs present in each preparation were counted and recorded.

Data management and analysis

Data was entered during and after data collection, coded and classified to adjust for any missing information. The primary data was entered into Microsoft Excel and then transferred to and analyzed using SPSS Version 12.0. Frequency tables and cross-tabulation were produced where appropriate and a logistic regression model was applied to identify explanatory variables that have a significant role in influencing dependent variables. Moreover, an association was made for the independent and dependent variables using a significance level set at $p= 0.05$. The mean prevalence of schistosomiasis allows a district to be classified as follows: non-endemic (0%), low (< 10%), moderate (10% to < 50%), or high (> 50%) risk (World Health Organization, 2014). The number of eggs per filter was counted, and the infection intensity was classified as light (<50 eggs/10 ml of urine) or heavy (≥50 eggs/10 ml of urine), as defined by the World Health Organization ("Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis.," 2002).

Ethical clearance

Ethical approval was obtained from the Senate Research and Publications Committee, and the Institutional Review Board of the Muhimbili University of Health and Allied Sciences (MUHAS) (Ref. MU/PGS/SAEC/Vol. IV/200). Permission to conduct the study in Morogoro Municipality was obtained from the Municipal Education Officer who issued written permission to the sampled schools. Written and verbal consent was obtained from the participants and their parents/guardians. During the survey arrangements were made with the nearest public health centre or dispensary for the possibility of treating children who were found to have urinary schistosomiasis.

Results

Background characteristics of the study area

The main water body identified in the area was the Morogoro river. This river runs across the study area. This was considered as a potentially infected water body even though there were no snails sampled from this river in the study. Sewage systems were observed to have outlets into the river and the major human water contact sites were identified. Water contact sites were observed to be regular swimming, bathing, fishing and crossing points for the pupils. Other various points on the river were used for washing, and collecting water for gardening. Other sites were not fully observed due to poor infrastructure.

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Demographic characteristics

The study involved a total of 884 pupils who were interviewed and their urine was screened for *S. haematobium* infection. In the schools sampled, the majority of students were from Kalakaua Primary School (16%), this was due to their willingness to participate in the study (Table 1). All school children sampled were from standard one to standard seven, females were 459 (51.9%) and males 425 (48.1%) with a mean age of 10.9 years (SD=2.4) for males and 10.6 (SD=1.7) years for Females.

Table 1: Distribution of pupils according to their schools. (N=884)

Name of school	N (%)
Bungo	117 (13.2)
Chamwino	133 (15.0)
Kilakala	141 (16.0)
Kiwanja cha ndege	70 (7.9)
Mchikichini	75 (8.5)
Mkwajuni	64 (7.2)
Mtawala	70 (7.9)
Mwembesongo	63 (7.1)
Mwere	90 (10.2)
Uhuru	61 (6.9)

Prevalence of S. haematobium among school pupils in the study population

The overall prevalence rate of *S. haematobium* infection was found to be 32.5% (287 pupils out of 884 (95% CI, -3.1- 5.6%) in the ten schools that were sampled. Furthermore, the prevalence was then analyzed within the age groups, whereby, in the age group 6-8 years only 35% had *S. haematobium* eggs, followed by the age group 12-14 years with 34.97%, 9-11 years with 30.95% and least infected was age group 15-16 years with 21.64% (Table 2).

Table 2: Prevalence of S. haematobium infection among age groups

	Age groups			
	6-8 years	9-11 years	12-14 years	15-16 years
With eggs in urine	35 (35%)	147 (30.95%)	100 (34.97%)	5 (21.74%)
Without eggs in urine	65 (65%)	328 (69.05%)	186 (65.03%)	18 (78.26%)
Total	100	475	286	23

Prevalence was again analyzed within each sex group. Within the male group, only 33.88% had *S. haematobium* eggs in their urine and 31.15% in the female group (Table 3).

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Table 3: Prevalence of *S. haematobium* by sex in the study population

	Sex of Pupil	
	Male	Female
With eggs in urine	144 (33.88%)	143 (31.15%)
Without eggs in urine	281 (66.12%)	316 (68.85%)
Total	425	459

Intensity of S. haematobium among school pupils in the study population

It was observed that 228/884 (25.8%) of the pupils had low infection intensity and 82/884 (9.3%) had high infection intensity. Further analysis was done on the pupils with *S. haematobium* infection (eggs) only. When the level of intensity was analyzed among age groups, the high infection intensity was observed in age group 6-8 years (35.14%), followed by age group 9-11 years (26.19%), age group 12-14 (24%) and age group 15-16 years (20%) (Table 4).

Table 4: Intensity of *S. haematobium* infection by age among students with infection

	Age groups			
	6-8 years	9-11 years	12-14 years	15-16 years
Low infection	24 (64.86%)	124 (73.01%)	76 (76%)	4 (80%)
High infection	13 (35.14%)	44 (26.19%)	24 (24%)	1 (20%)
Total N (%)	37	168	100	5

Furthermore, the level of intensity was then calculated within sex groups, results showed that in males, high infection intensity was 31.54% while in females was 23.18% (Table 5).

Table 5: Intensity of *S. haematobium* infection by sex among students with infection

	Sex of Pupil	
	Male	Female
Low infection	112 (70.44%)	116 (76.82%)
High infection	47 (31.54%)	35 (23.18%)
Total N (%)	159	151

Relationship between blood in urine in the past year and S. haematobium eggs

The study assessed if pupils had observed blood in their urine within the past year at the time of the study. Almost twenty-eight per cent (27.83%) of the pupils observed blood in their urine. The relationship between pupils who urinated blood in the past year and those who were found to have *S. haematobium* eggs in the urine was then analyzed. The odds that a pupil who urinated blood in the past year and had *S. haematobium* eggs was 16.11 more likely than those pupils that did not observe blood in their urine, which was statistically significant (95% CI 11.06%,23.28%, p-value <0.001) (Table 6).

Table 6: Relation between pupils that urinated blood within the past year and *S. haematobium* eggs in their urine.

	S. haematobium eggs in urine	Odds ratio	95% Confidence intervals

Urinated blood in the past year	246 (27.83%)	16.11	11.06 - 23.48

p-value<0.001

Urinating habits of primary school pupils

The study determined that 287 pupils out of the 884 sampled pupils frequently swam in water bodies (rivers, dams, streams, ponds). Further analysis was done to determine the response within the age groups. Generally, most pupils did not urinate in water in all age groups, however, for those that did, in age groups 6- 8 years 34.29% urinated in water while age group 15-16 years was 40% which accounted for only 2 students (Table 7).

Table 7: Urinating habits of pupils who swim in water bodies in the study population

swimming in water bodies where do you urinate	Age groups			
	6-8 years	9-11 years	12-14 years	15-16 years
Urinate in water	12 (34.29%)	61 (41.5%)	29 (29%)	2 (40%)
Urinate out of water	23 (67.71%)	86 (58.5%)	71 (71%)	3 (60%)
Total	35	147	100	5

In instances where toilets were not available to pupils, alternative accommodations were assessed. The answers were analyzed based on the provided options for answers (bushes, rivers. Streams, farms) and 2.38% of pupils urinated in rivers while the majority 95.14% did not pick any of the provided options (Table 8).

Table 8: Alternative areas pupils urinated when are not available at home or school

If toilets are not available where else do you defecate?	
	N (%)
Bushes	12 (1.35)
Rivers	21 (2.38)
Streams	4 (0.45)
Farms	6 (0.68)
Other	841 (95.14)
Total	884 (100)

Risk factors for S. haematobium among pupils in the study population

The risk factors were then analyzed to see the association between those factors and *S. haematobium* infection to see if they contributed to putting a pupil at risk of having *S. haematobium* infection. Those pupils that bath in rivers, ponds, dams or streams were 7 times more at risk of being infected with *S. haematobium* than the pupils that did not bathe in the water bodies. The pupils who played in the water were 3.7 more times at risk of being infected than those pupils who did not play in the water. And those who went fishing were 4 times more at risk of being infected with the parasite than those who did not fish. These above-mentioned risk factors are statistically significant (Table 9).

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Table 9: Association between Risk factors of S. haematobium and eggs in pupil's urine

Variable		*S. haematobium* eggs		Total	Odds ratio	95% CI
		Yes	No			
Sex of respondent						
	Male	144 (50.2%)	281 (47.1%)	425 (48.1%)	1.1	0.9-1.5
	Female	143 (49.8%)	316 (52.9%)	459 (51.9%)		
Did you take PZQ in the last MDA?						
	Yes	252 (87.8%)	506 (84.8%)	758 (85.7%)	1.3	0.8-2.0
	No	35 (12.2%)	91 (15.2%)	126 (14.3%)		
Do you like playing in water (not necessarily swimming)?						
	Yes	186 (64.8%)	197 (33.1%)	383 (43.4%)	3.7	2.7-5.1
	No	101 (35.2%)	399 (66.9%)	500 (56.6%)		
Do you bathe in a river/pond/dam/stream?						
	Yes	224 (78.0%)	202 (33.8%)	426 (48.2%)	7	5.0-9.8
	No	63 (22.0%)	395 (66.2%)	458 (51.8%)		
Do you go fishing?						
	Yes	71 (24.7%)	45 (7.5%)	116 (13.1%)	4	2.6-6.2
	No	216 (75.3%)	552 (92.5%)	768 (86.9%)		
Do you help your parents work in rice fields?						
	Yes	67 (23.3%)	104 (17.4%)	171 (19.3%)	1.4	1.0-2.1
	No	220 (76.7%)	493 (82.6%)	713 (80.7%)		

Primary school pupils carrying S. haematobium eggs and have hematuria in the study population

Pupils who had *S. haematobium* infection (eggs) in their urine were then analyzed for macro-hematuria and micro-hematuria. The total number of pupils that had *S. haematobium* infection was 287, where by 116 (40.42%) of them had micro-hematuria (Table 10).

Table 10: Proportion of pupils with microhematuria and *S. haematobium* infection

Macrohematuria	N
Present	116 (40.42%)
Absent	171 (59.58%)
Total	287

For micro-hematuria, the results showed that 276 (96.17%) of pupils that had *S. haematobium* infection also had red blood cells in their urine, which is an indicator of micro-hematuria (Table 11).

Table 11: Proportion of pupils with microhematuria and *S. haematobium* infection

Microhaematuria	N (%)
RBCs present	276 (96.17)
RBCs not present	11 (3.83)

Total	287 (100)

Praziquantel uptake among pupils in the study area

Out of the 884 students sampled, 126 (14.3%) took praziquantel in the last annual MDA and 758 (85.7%) did not take praziquantel (Table 12).

Table 12: Sex of pupils who took Praziquantel in the last annual administration

Sex	Did you take PZQ in the last MDA?	
	Yes	No
Male	56 (13.2)	369 (86.8)
Female	70 (15.3)	389 (84.70)

PZQ; Praziquantel

The relationship between those pupils who received praziquantel in the last MDA and had *S. haematobium* infection (eggs) was observed. 3.96% of pupils who received praziquantel in the last general administration also had *S. haematobium* infection and the odds of having infection despite taking the drug was 0.77 (95% CI 0.5-1.2) (Table 13).

Table 13: Relationship of Praziquantel intake with the presence of *S. haematobium* eggs in pupil's urine

S. haematobium eggs	Praziquantel uptake			
	Yes	No	OR	95% CI
Absent	91 (10.29)	506 (57.24)	0.77	0.5-1.2
Present	35 (3.96)	252 (28.51)		

Discussion

This study was undertaken two years after the last mass distribution of praziquantel to primary school pupils of Morogoro municipality. At this time all pupils and teachers were aware of the MDA and effort put into controlling urinary schistosomiasis. Schools sampled were ten and from each school, the number of pupils sampled varied. Many pupils sampled were females 459 (51.9%) with a mean age of 10.6 years. From data obtained from the Primary school Municipal Education Office, more female pupils were enrolled in schools compared to males hence a possible explanation as to why there were more female pupils sampled compared to male pupils. The male pupils were 425 (48.1%) and a mean age of 10.9 which is slightly higher than that of females. These mean age falls under the peak age of being at risk of being infected by *S. haematobium* that has been found in other studies such as the one done in Nigerian primary schools whereby both the prevalence and intensity of infection were found to be the highest in children aged 10± 14 years (Ejezie & Ade-Serrano, 1981).

Prevalence and infection intensity of S. haematobium among school pupils

The overall prevalence of *S. haematobium* infection in Morogoro municipality was found to be 32.5% respectively. These findings corroborate the results of previous studies conducted in the country (Brooker et al., 2001; Clements et al., 2006; Mazigo et al., 2022). However, the prevalence obtained in this study is lower compared to the previous prevalence reported in the area of 85% prevalence (Morogoro Municipal Council, n.d.) but confirms that *S. haematobium* is still a disease that needs controlling. The difference in prevalence may be attributed to different seasons when the study was carried out since there is seasonal variation in the transmission of *S. haematobium* infection (Webbe & Jordan, 1966). In addition, it may be due to the ongoing schistosomiasis control initiative of MDA with praziquantel (Ministry of Health Tanzania, 2010).

The overall intensity in this study of *S. haematobium* infection in Morogoro municipality was 35.1% respectively. To understand better the level of infection intensity aggregate it in age and sex groups. Generally, in all age groups, the intensity was low, but notable within the 6-8 years age group, previously reported to be at high risk of infection in other areas (Brooker et al., 2001; Clements et al., 2006; Mazigo et al., 2012, 2022; Sarda et al., 1985) and other countries (Ejezie & Ade-Serrano, 1981; Santos et al., 2021; Umoh et al., 2020) where *S. haematobium* infection is endemic. An earlier report indicated the distribution of schistosomiasis in endemic communities fits a negative binomial curve, with most infected persons harboring low worm burdens and only a small proportion having heavy infections (Mahmond, 2000). This may explain the trend observed in this study. However, the aggregation of worm burden in a small proportion of infected individuals may have multiple explanations including genetic susceptibility (Secor et al., 1996).

In addition, the variation in the intensity of infection depends partially on the different levels of endemicity, the season when the study is conducted, the methods used and, the time, when urine specimens are collected for analysis (Ndyomugyenyi & Minjas, 2001). The age of pupils also factors in when prevalence and intensity are being calculated and in this study the pupils between the ages of 6-11 years old had the high prevalence and intensity. The prevalence and intensity often observed in this age group have been attributed to high human-water contact and exposure to infection (Mazigo et al., 2012).

Hematuria among school pupils

The classical sign of urinary schistosomiasis is hematuria (Carabin et al., 2000; GUYATT et al., 1994). Hematuria is correlated with the intensity of the infection (Wilkins et al., 1979, Mott et al., 1983, Tanner et al., 1983). This study observed a relationship between urinating blood in the past and S. *haematobium* infection. Even though the pupils who urinated blood and were found to have infection were only 27.83% they were 16.1 times more likely to be at risk of getting infected than the pupils who did not urinate blood in the past. The prevalence of microhematuria was 96.17% and that of microhematuria was 40.42% in pupils that had *S. haemotobium* infection.

The study observed an overlap of microhematuria and microhematuria, in infected pupils. Pupils that had macrohematuria were all positive for microhematuria but those with microhematuria were not all positive for macrohematuria. This was a single-day result from the filtration technique to determine hematuria. This has the disadvantage of the inadequacy of a single urine filtration to determine *S. haematobium* eggs. A study done in Ifakara, Tanzania, observed that single-day results were negative despite high intensity (>50 eggs/10ml urine) of infection on other days (Berhe et al., 2004). For those pupils, hematuria was observed but no eggs were detected. This could be explained by other infections such as Urinary Tract Infections, menstrual bleeding in older female pupils and other medical conditions that were not examined in this study. In this study, observation was by the naked eye looking at the various shades of urine whereby there were three options, yellow, light red and dark red and no reagent strips were used.

Another study carried out in the Ilala district, used chemical reagent strips and reported a sensitivity of 84.3% (Ndyomugyenyi & Minjas, 2001). That same study used the history of hematuria as a second sensitive indirect method to identify infected pupils (60.4%), visual observation was the least sensitive (37.7%) but the most specific (91.7%). Therefore, school-based questionnaire methods reporting the occurrence of red urine can also be useful for targeting, or eliminating, areas for treatment where urinary schistosomiasis is likely endemic.

Risk factors for S. haematobium among school pupils

In a study done in Ghana investigating the relationship between water contact habits of males and females to prevalence, observed that among male pupils 41.2% engaged in swimming activities whereas only 29.3% of females were involved. Also 36.7% of the males and 32.6% of the females bathed in a river. Other activities in the water like washing dishes and clothes attracted 22.0% and 38.0% of males and females respectively (JO Awotunde EO Okanla BN Agba, 2002). Recreational water activities such as swimming and playing in water have been observed to result in more frequent and intensive infection with potentially infective water in Egypt (H Kloos, 1982), South Africa (Kvalsvig & Schutte, 1986) and Tanzania (Landier et al., 2016).

In this study, urinating habits were observed from pupils who went swimming in rivers and those who at one point or another lacked a functioning toilet at home or school and hence urinated in rivers, streams or dams. Among the sampled pupils 41.5% in the age group 9 to 11 years admit to urinating in the water while swimming. Other studies have shown that transmission of urinary schistosomiasis occurs when the infected person urinates in the water bodies which serve as a source of drinking or bathing, thereby introducing eggs which hatch into larvae that infect the snail hosts (Grácio et al., 1992). This study also explored risk factors that might have contributed to the transmission of *S. haematobium*. The pupils who fish, play and/or bathe in rivers, ponds, dams or streams, are more at risk of being infected with *S. haematobium* compared to pupils who did not engage in these activities. These noted risk factors play a role in exposing a pupil to being infected with the parasite and this was observed in other studies such as the one done by Engles and Savoli, that state *S. haematobium* infection is acquired through exposure to unsafe environmental water infested with schistosome larvae (Engels & Savioli, 2006).

Praziquantel uptake among primary school pupils in the study population

The use of chemotherapy in the control of schistosomiasis was advocated a while back but a driving force came when the price of praziquantel was reduced. In addition, as part of the World Health Assembly 54.19 resolution, deworming is firmly on the international health agenda and increasing access to ant-helminthics, particularly in SAC, is a key target promoted by the WHO (Savioli et al., 1997). Over the current years, praziquantel has been distributed to primary school children in Morogoro region. This was taken into consideration in this survey and the results show that 14.3% of students took praziquantel in the last annual distribution in Morogoro Municipal.

According to the Schistosomiasis Initiative Control Program, Morogoro region had the lowest coverage among all regions that received Praziquantel in MDA (Neglected Tropical Diseases Program Tanzania, 2023). The pupils experienced side effects such as fainting that created panic throughout the community hence led to parents refusing their children to participate in the MDA. Those who took praziquantel in the last general distribution and yet had *S. haematobium* infection were few (3.96%) compared to those who did not take praziquantel in the last general distribution (10.29%). The lack of difference may be attributed to the fact that even the students who did agree to have taken the drug in the last general distribution might have lied or they truly did take the drug and managed to stay from contaminated waters.

Praziquantel should still be advocated and distributed since the information about the accuracy of its distribution in the last round in the study area is sketchy. The study was a cross-sectional study that was limited in exploring the seasonal variation in *S. haematobium* transmission and other environmental and genetic factors that influence the prevalence and transmission of this disease.

Conclusions

This study provides an important observation on the status of infection in this urban area of Tanzania and exemplifies the national efforts to advance active participation in schistosomiasis prevention and control activities at the sub-district levels. The study revealed that the prevalence of *S. haematobium* among primary school children in Morogoro municipality was 32.5% and MDA with praziquantel coverage was 14.3%. This study also revealed the risk factors that contributed to *S. haematobium* infection among pupils. Factors such as playing in water, bathing in rivers, ponds, dams or streams, and fishing, were found to have a statistical significance in contributing to *S. haematobium* infection among the pupils. Praziquantel uptake was very low in the study population which was explained by the severe negative side effects the pupils experienced. These results could be a reflection of other parts of the country in the uptake of MDA, hence, much effort is needed to restore the faith in mass administration of praziquantel.

Complementary integrated control activities, such as environmental management measures, should be planned with other sectors such as agriculture and water resource development programs. It is also important to ensure that any development activity likely to favour the emergence or spread of schistosomiasis and other parasitic diseases is preceded by a proper health impact assessment and accompanied by preventive measures to limit their impact.

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Authors' contributions

TEN conceived, collected data, performed analysis, data interpretation and wrote and approved the manuscript.

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Competing interests

The author declares that she has no competing interests.

Availability of data and material

All data generated or analyzed during this study are included in this published article.

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