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Intestinal schistosomiasis among secondary school students in Northern Tanzania: prevalence, infection intensity and associated risk factors

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ABSTRACT

Objective: Our study investigated the prevalence, infection intensity and associated risk factors of intestinal schistosomiasis among secondary school students in Shinyanga Municipal Council, Northern Tanzania.
Methods: A quantitative school-based cross-sectional study was conducted from June to August 2022 among 620 secondary students. One stool specimen per participant was collected and screened for *Schistosoma mansoni* ova by microscopy using the Kato-Katz technique. Ova were counted to estimate infection intensity in all positive stool samples. Participants' socio-demographic characteristics and risk factors for intestinal schistosomiasis were gathered using a structured questionnaire. Data analysis consisted of descriptive statistics, Chi-square test and logistic regression.
Results: Overall prevalence of *S. mansoni* was 1.9%. All infected participants had light infection intensity. Overall prevalence of other intestinal parasites was 2.7%, with Hookworm spp (17.6%) and *Entamoeba coli* (52.9%) the most observed intestinal helminth and protozoa, respectively. Among assessed factors, being in form II or III, visiting water sources and doing activities in water sources were statistically significantly associated with increased risk of *S. mansoni* transmission.
Conclusions: There is ongoing transmission of intestinal schistosomiasis among secondary students. Hence, the need for extending praziquantel administration in this group, health education provision, and improvement of water supply, sanitation and hygienic practices.

Introduction

Intestinal schistosomiasis is a chronic, neglected parasitic disease caused by the parasite trematode of the genus *Schistosoma.* Five *Schistosoma* species (*Schistosoma mansoni, Schistosoma japonicum, Schistosoma mekongi, Schistosoma guineensis, Schistosoma intercalatum*) are known to cause intestinal schistosomiasis in tropical and subtropical regions [26]. Intestinal schistosomiasis is most common in poor communities, with inadequate water supply and sanitation facilities and improper hygienic practices (WaSH) ([9,10]). Pre and school-aged children and adults engaging in water contact activities are at high risk of acquiring the infection [26]. Intestinal schistosomiasis transmission occurs when water sources are contaminated with viable *S. mansoni* ova, there is a presence of Biomphlaria snail species (intermediate host) which favor the cercariae development, and human contact with the cercaria-infested water [26].

Globally, 393 million people are at risk of acquiring intestinal schistosomiasis, with over 54 million infected and approximately 200,000 deaths yearly. Over 90% of intestinal schistosomiasis burden is in sub-Saharan Africa, with *S. mansoni* being the causative agent [26]. *S. mansoni* is responsible for the significant morbidity among the infected individuals by damaging their organs through the formation of granuloma around the ova in the tissues leading to fibrosis and chronic liver inflammation and later on causing severe bleeding, renal failure and cancer [28]. In school children, intestinal schistosomiasis infestation can lead to poor growth, malnutrition, poor cognitive function and the de-

Abbreviations: MDA, Mass Drug Administration; NTDCP, Neglected Tropical Diseases Control Programme; WaSH, Water, Sanitation and Hygiene; WHO, World Health Organization.

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velopment of hepatosplenic morbidities characterized by splenomegaly, hepatomegaly and progressive periportal fibrosis [22,28].

Tanzania is a schistosomiasis-endemic country ranking second after Nigeria in terms of its burden [25], with 51.5% of the population either infected or at risk of acquiring the infection [14]. The distribution of *S. mansoni* is focal, with the most extensive zones found in southwestern and southeastern Lake Victoria and its island in Northern Tanzania. The prevalence of intestinal schistosomiasis varies in the country, with up to 100% prevalence on the shores of Lake Victoria [14]. The high prevalence of intestinal schistosomiasis led to the introduction of the mass drug administration (MDA) with praziquantel in 2006 [16]. However, this intervention has focused on primary school-aged children only, leaving other populations at risk, such as under-fives and secondary school students, which could be the reservoir of the infection. MDA of praziquantel and albendazole has been beneficial in preventing schistosomiasis and soil-transmitted helminths among primary school children in endemic communities [8]. In addition to MDA, health education on the importance of preventive chemotherapy was initiated for primary students to increase its uptake [16].

Shinyanga Municipal Council is located in Northern Tanzania and is endemic to intestinal and urogenital schistosomiasis [24]. Despite being endemic, there is a paucity of epidemiological data on its burden, intensity and associated risk factors. The new World Health Organization (WHO) guideline for human schistosomiasis control and elimination emphasizes the importance of expanding praziquantel MDA to other at-risk populations in endemic areas, in addition to primary school-aged children who are currently the only beneficiaries of the interventions. For this to happen, epidemiologic data on disease burden and transmission dynamics are crucial. Therefore, our study investigated the prevalence, infection intensity and associated risk factors of intestinal schistosomiasis among secondary school students in Shinyanga Municipal Council, Northern Tanzania. The collected data will reveal the current burden of the disease and associated risk factors which will be vital to the Neglected Tropical Diseases Control Programme (NTDCP) for effective control strategies planning for this group.

Materials and methods

Study area and demographics

Shinyanga Municipal Council (MC) is the only municipal council out of the 6 councils forming the Shinyanga Region. The council is located between latitude 3° 39′ 36″ S and 33° 25′ 12″ E longitude. The municipal council is boarded north by the Mwanza region, south by Shinyanga rural district, east by the Kishapu District, and west by the Kahama and Geita Districts [19]. The MC has an area of 584 km^2 with an approximate population of 161,391 (78,655 male, 82,736 female) and a 4.8% average household size [20].

The Shinyanga Municipal Council has 3 divisions, 17 wards, 19 villages, 25 streets and 95 hamlets, all potentially endemic to intestinal schistosomiasis [19]. The prevailing climate is tropical, with distinct rainy and dry seasons. The average annual rainfall is 600–1000 mm, with an average temperature of 18–31°C [19].

The environment of the Shinyanga is characterized by black cotton soil and non-permanent streams that flow after rain. The main economic activities are small-scale agriculture, livestock farming and crop production. Pools and ponds along dry riverbeds, and artificial pools shared by domestic livestock, are the primary water sources. Irrigation is practiced during the dry season, creating an ideal environment for Schistosoma snail vectors' breeding and survival [1]. The Shinyanga MC was selected due to its schistosomiasis endemicity and the lack of snail control interventions.

Study design and population

A quantitative school-based cross-sectional study was conducted from June to August 2022 to investigate the prevalence, infection intensity and associated risk factors of intestinal schistosomiasis among secondary school students. The study population was secondary school students attending secondary schools in Shinyanga MC. The inclusion criteria were: age 11–20 years, being a form I–IV student and being a permanent resident of Shinyanga MC. Students who had taken praziquantel 1–3 weeks before the study were excluded. The study participants were considered positive based on the actual results of laboratory investigations rather than a clinical interview on the previous history. In this sense, recent treatment of a disease would have biased the results by lowering prevalence. The inability to complete the questionnaire and provide stool samples for laboratory investigations was also an exclusion criterion since their inclusion would have resulted in missing data.

Sample size determination and sampling

The estimation of the sample size was carried out using the formula for cross-section study ($n = z^2 P (100-P)/ \varepsilon^2$) ([7]), assuming a standard normal deviate of 1.96 at 95% CI, the prevalence of 50% because of the absence of intestinal schistosomiasis studies in secondary students at Shinyanga, and 5% margin of error. Then the sample size was adjusted for non-response (10%) and designing effect (1.5%). Thus, the estimated sample size was 634 secondary students.

The 634 secondary students were sampled using a multistage sampling technique. In the first stage, 4 wards were selected randomly out of 17 (Ibadakuli, Iselamagazi, Mwamalili and Mwawaza). In the second stage, one secondary school was randomly selected from each ward. The randomly selected schools were Uzogore, Iselamagazi, Mwamalili and Mwawaza Secondary Schools from Ibadakuli, Iselamagazi, Mwamalili and Mwawaza wards. The total number of secondary students in each of the selected schools was used to estimate the number of students to be sampled per school, with a school having a high number of students contributing to a higher number of participants. At the end of the sampling, only 620 students were recruited, with 14 secondary school students dropped due to failure to provide stool samples.

Sample collection and processing

A single fresh stool sample was collected using labeled sterile and wide-mouthed plastic containers from participants recruited in this study. Before stool collection, participants were oriented on stool collection procedures and instructed to bring a sufficient amount of stool sample. The collected stool samples were preserved by fixing them with 10% formalin, packed in boxes and transported to the Parasitology laboratory at the Muhimbili University of Health and Allied Sciences in Dar es Salaam for processing. In the parasitology laboratory, the stool samples were checked for identification numbers, quantity and quality, and then duplicate thick smears were prepared and processed using the Kato-Katz technique [6] and examined microscopically for *S. mansoni* eggs. The Kato-Katz thick smears were prepared using the 41.7 mg template and re-read by 2 independent laboratory scientists. The *S. mansoni* intensity was classified based on WHO criteria, where 1–99 eggs per gram (EPG) is light infection, 100–399 EPG is moderate infection, and ≥400 is heavy infection ([27]).

Questionnaire survey

The questionnaire was adopted [17], modified, and pre-tested before data collection. The self-administered questionnaire had 5 sections (1-5) for socio-demographic characteristics of the study participants; knowledge, attitudes and practices on intestinal schistosomiasis; and WaSH risk factors that could lead to intestinal schistosomiasis.

Outcome and independent variables

The outcome was a prevalence of intestinal schistosomiasis reported as positive if *S. mansoni* ova was found or negative if no *S. mansoni* ova

were found. For the positive samples, the outcome was further categorized as light, moderate or heavy intensity of infection. The independent variables were socio-demographic characteristics such as sex (male or female), age group (11–15 and 16–20 years), school class (form I to IV), residency (≤10 and 11–20 years) and school. Other independent variables were "knowledge" classified as high, moderate or low level, "attitude" classified as negative or positive, "practices" classified as appropriate or inappropriate and WaSH risk factors.

Quality control

For quality control, the questionnaire was pre-tested in 10% of the estimated sample size at Lyabusalu Secondary School. Based on the results of the pre-testing, the questionnaire was modified. The school used for pre-testing was excluded during the actual data collection. In addition, approximately 20% of the stool samples examined were re-examined by a senior laboratory scientist from the parasitology laboratory at Muhimbili University, who was blinded to the initial results.

Data analysis

Data was entered and analyzed using the statistical package for the social sciences (SPSS) version 21 (IBM Corp., Armonk, NY, USA). The categorical variables were summarized using descriptive statistics into frequencies, proportions and 95% CIs. The prevalence of intestinal schistosomiasis and infection intensity were summarized based on the participants' socio-demographic characteristics, with a comparison of proportions carried out using the Pearson chi-square at a significance level of 5%. The risk factors for intestinal schistosomiasis were assessed using univariate logistic regression. At a significance level of 5%, factors with a *p*-value of 0.25 were subjected to multivariate logistic regression to obtain the adjusted odds ratio (AOR).

Knowledge was measured using a scoring scale with 7 questions carrying a weight of 15 marks. The responses were marked 1 for correct and 0 for incorrect, then each individual's scores were added to create a scale ranging from 0 to 15 marks. Final scores were used to classify knowledge levels into low (<5 marks), moderate (6–10 marks) or high (11–15 marks). Attitudes and practices were measured using 10 statements each on a 5 point-Likert scale, making a scale of 10 to 50 points. The attitude statements had reliability analysis and Cronbach's alpha value of 0.753, while the practice statements had 0.618. The mean attitude score (41.8) and practices score (35.8) were used to categorize attitudes into positive (42–50) or negative (≤41) and practices into appropriate (37–50) or inappropriate (≤36).

Results

Socio-demographic characteristics of study participants

Of the 620 participants, more than half were female (59.8%). Ages ranged from 11–20 years, with a mean age of 15.87. The majority (73.9%) were residents of the Shinyanga MC for 11–20 years (Table 1).

Prevalence and intensity of intestinal schistosomiasis among study participants

The overall prevalence of *S. mansoni* was 1.9%, with a mean infection intensity of 46.08 ± 32.78 EPG. The higher prevalence was observed among males (2.8%), the 16–20 years age group (2.4%), form IV students (6.2%) and residents of the Shinyanga MC for ≤10 years (2.5%). Of the 4 secondary schools that participated in this study, only 2 (Iselamagazi [3%] and Mwamalili [1.2%] secondary schools) had schistosomiasis infection. There was a statistically significant difference between *S. mansoni* prevalence and school class (p=0.010) (Table 2). All of the 12 infected participants had light infection intensity.

Table 1
Socio-demographic characteristics of the study participants (n=620).

Variable	n (%)	95% CI
Sex		
Male	249 (40.2)	36.3-43.9
Female	371 (59.8)	56.1-63.7
Age group (years)	**15.87 ± 1.49**	
11-15 years	245 (39.5)	35.6-43.4
16-20 years	375 (60.5)	56.6-64.4
Class		
Form I	285 (46.0)	41.9-50.2
Form II	164 (26.5)	23.4-30.0
Form III	123 (19.8)	16.6-22.9
Form IV	48 (7.7)	5.6-10.0
Residency (years)	**12.70 ± 5.45**	
≤ 10 years	162 (26.1)	22.8-29.5
11-20 years	458 (73.9)	70.5-77.2
Schools		
Iselamagazi Secondary School	337 (54.4)	50.2-58.4
Mwamalili Secondary School	170 (27.4)	24.0-31.3
Mwawaza Secondary School	77 (12.4)	9.9-14.7
Uzogore Secondary School	36 (5.8)	4.0-7.6

Table 2
Prevalence and intensity of intestinal schistosomiasis according to the socio-demographic characteristics of the study participants (n=620).

Variable	Total	*S. mansoni* prevalence (%)	p-value	Average ova counts ± SD
Sex				
Male	249	07 (2.8)	0.159	56.71 ± 29.82
Female	371	05 (1.3)		31.20 ± 33.86
Age group (years)				
11-15 years	245	03 (1.2)	0.299	47.33 ± 14.64
16-20 years	375	09 (2.4)		45.67 ± 37.72
Class				
Form I	285	04 (1.4)	0.010*	50.25 ± 29.43
Form II	164	00 (0.0)		-
Form III	123	05 (4.1)		50.40 ± 36.84
Form IV	48	03 (6.2)		33.33 ±39.63
Residency (years)				
≤ 10 years	162	04 (2.5)	0.566	37.25 ± 31.77
11-20 years	458	08 (1.7)		50.50 ± 34.48
Schools				
Iselamagazi Secondary School	337	10 (3.0)	0.200	46.60 ± 32.12
Mwamalili Secondary School	170	02 (1.2)		43.50 ± 50.21
Mwawaza Secondary School	77	00 (0.0)		-
Uzogore Secondary School	36	00 (0.0)		-
Total	**620**	**12 (1.9)**		**46.08 ± 32.78**

*Statistically significant (p< 0.05).

Prevalence of other intestinal parasites among study participants

The prevalence of other intestinal parasites was 2.7%. A higher prevalence of other intestinal parasites was observed among the males (3.2%), age group 11–15 years (3.3%) and residents of the Shinyanga MC for 11–20 years (4.1%) (Supplementary Table 1). The most prevalent intestinal helminths and protozoa were hookworm (17.6%) and Entamoeba coli (52.9%), respectively (Figure 1).

Knowledge of intestinal schistosomiasis among study participants

Most study participants (91.6%) had heard about intestinal schistosomiasis, with school being the leading source of information (53.7%). The majority correctly knew intestinal schistosomiasis transmission is by contact with infested water (80.6%) and about the use of anti-schistosomal tablets for intestinal schistosomiasis treatment (77%). However, only 36.8% knew about using anti-schistosomal tablets for disease prevention (Table 3).

Table 3
Knowledge on the intestinal schistosomiasis among study participants (n=620).

Variable	n (%)	95% CI
Heard of intestinal schistosomiasis		
Yes	568 (91.6)	89.3-93.8
No	52 (8.4)	6.2-10.7
Source of the information		
School	305 (53.7)	49.5-57.7
Dispensary	125 (22.0)	18.9-25.5
Mass media	89 (15.7)	12.8-18.8
Home	43 (7.6)	5.4-9.7
Friend	06 (1.1)	0.3-2.0
Mode of intestinal schistosomiasis transmission		
By contact with infested water	458 (80.6)	77.1-83.6
By drinking contaminated water	70 (12.4)	9.7-15.0
By eating contaminated food	15 (2.7)	1.4-4.3
By hands shaking	12 (2.1)	1.1-3.2
By playing with dirty soil	04 (0.7)	0.2-1.4
Do not know	09 (1.6)	0.7-2.7
Do snails transmit intestinal schistosomiasis		
Yes	503 (88.6)	86.0-91.2
No	19 (3.4)	1.8-4.9
Do not know	46 (8.1)	5.8-10.2
Symptoms of intestinal schistosomiasis		
Stomach ache	250 (44.0)	39.8-48.1
Blood in feaces	113 (19.9)	16.6-23.0
Swollen stomach	81 (14.3)	11.5-17.5
Fever	15 (2.7)	1.4-4.1
Coughing	13 (2.3)	1.2-3.6
Itching	11 (1.9)	0.9-3.1
Diarrhea	24 (4.2)	2.7-6.0
Headache	06 (1.1)	0.3-1.9
Do not know	55 (9.7)	7.4-12.2
Is intestinal schistosomiasis treated?		
Yes	512 (90.1)	87.5-92.6
No	08 (1.4)	0.5-2.4
Do not know	48 (8.5)	6.0-10.9
Ways to treat intestinal schistosomiasis		
By using anti-schistosomal tablets	394 (77.0)	73.2-80.5
By administration of the injection	41 (8.0)	5.8-10.5
By using traditional herbs	20 (3.9)	2.3-5.8
By being operated	19 (3.7)	2.3-5.5
Do not know	38 (7.5)	5.3-9.8
Is intestinal schistosomiasis preventable?		
Yes	506 (89.1)	86.5-91.4
No	18 (3.2)	1.9-4.7
Do not know	44 (7.8)	5.7-9.8
Ways to prevent urogenital schistosomiasis		
Use of anti-schistosomal tablets	186 (36.8)	32.8-40.9
By avoiding contact with unprotected water bodies	185 (36.6)	32.5-40.7
By improving of personal hygiene	63 (12.5)	9.4-15.5
Use of piped water	40 (7.9)	5.5-10.5
Use of latrines	23 (4.6)	2.8-6.6
Do not know	09 (1.8)	0.8-3.1

Knowledge levels according to the socio-demographic characteristics of study participants

None of the study participants had a high level of knowledge. The lower level of knowledge was more common among female participants (23.3%), age group of 11–15 years (29.6%), form I students (28.2%), and residents of Shinyanga MC for ≤10 years (24.3%). There were statistically significant differences between levels of knowledge across the age groups (p=0.001) and school classes (p=0.010) (Table 4).

Attitudes and practices on intestinal schistosomiasis among study participants

More than two-thirds of the study participants (68.1%) strongly agreed that intestinal schistosomiasis is a serious disease. Nearly two-thirds strongly agreed that periodical screening for intestinal schistosomiasis is crucial (64.4%) and that it is important to take anti-schistosomal tablets for disease prevention (63.4%) (Figure 2).

Study participants strongly agreed that one could acquire intestinal schistosomiasis through using infested water for domestic activities (62.7%), swimming and playing in infested water (60.4%), and crossing infested water sources barefooted (47.1%). In addition, nearly two-thirds of participants strongly agreed that defecation in water sources perpetuates the transmission of intestinal schistosomiasis (63.1%) (Figure 3).

Classification of attitudes and practices according to participants' socio-demographic characteristics

Negative attitudes were high among the 11–20 years age group (51.8%) and form I students (57.2%), while inappropriate practices were highest among form I students (63.5%) and students of Mwamalili Secondary School (69.4%). There was a statistically significant difference between attitude level and age group (p=0.035) and school classes (p<0.000). Similarly, there was a statistically significant difference between the level of inappropriate practices and school classes (p<0.000) and school (p<0.000) (Table 5).

Water, sanitation and hygiene status of study participants

Most study participants reported visiting water sources (83.9%), with ponds being the most visited (61.9%). The majority (94.9%) reported carrying on activities in or near water sources; however, few reported practising open defecation in water sources (15.4%). A high prevalence of intestinal schistosomiasis was observed among participants visiting and carrying on activities in or near the water sources (Table 6).

Factors associated with intestinal schistosomiasis transmission among study participants

In univariate analysis, the predictors of intestinal schistosomiasis transmission were participants' sex, school class, knowledge, attitudes, practices, the habit of visiting water sources, swimming and carrying out activities in or near water sources. In multivariate analysis, the odds of intestinal schistosomiasis transmission were high among the participants who visited water sources (AOR: 4.31 95% CI: 3.35–6.27) and who carried out activities in water sources nearby (AOR: 1.70 95% CI: 1.56–1.97), especially laundry and washing dishes (AOR: 18.58 95% CI: 0.74–21.53) (Table 7).

Discussion

Our study is one of the few in Tanzania that has established the prevalence, infection intensity and risk factors for intestinal schistosomiasis among secondary students. The majority of available studies focus on primary school students while neglecting other populations that could act as an infection reservoir in the community. The overall prevalence of *S. mansoni* was 1.9%, with all infected study participants having a light infection, indicating the ongoing transmission of intestinal schistosomiasis among secondary students in Shinyanga. The observed prevalence is lower compared with findings from Nigeria of 2%–9% prevalence among secondary students ([5]; Ojo *et al.*, 2021). The disparity in prevalence between studies may be attributed to different types of water sources utilized or visited, the time the survey was carried out and socioeconomic and environmental factors.

The prevalence and mean intensity of intestinal schistosomiasis was high in male study participants compared with female, probably influenced by more frequent engagement in water contact activities compared with their female counterparties, hence increased exposure to cercariae-infested water. The finding is similar to that reported in Nigeria, indicating the high prevalence of the disease in males was contributed to by the male habit of swimming which females were not al-

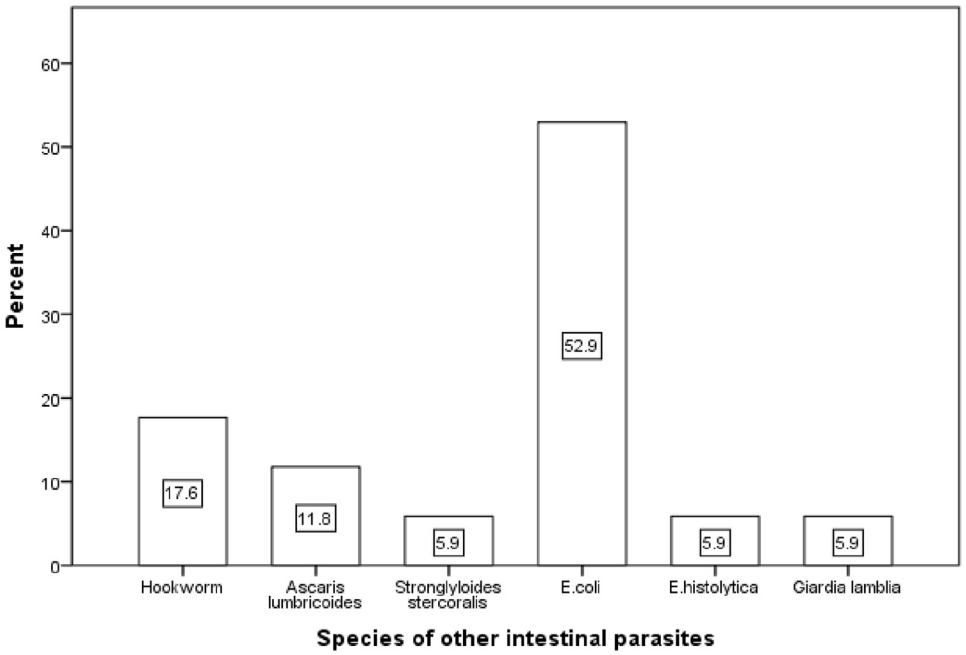

Figure 1. Prevalence of other intestinal parasites among study participants.

lowed to do [5]. The prevalence of intestinal schistosomiasis increased as age increased, probably due to the frequency of contact with contaminated water over time. The finding is in line with the studies conducted elsewhere ([5,21]). The mean intensity was higher in the 11–15 years age group compared with the 16–20 age group. Studies have reported intestinal schistosomiasis intensity peaks between the ages of 10 and 20 years, with a gradual decline of infection burden as partial immunity to new infections develops [4,15].

The prevalence of other intestinal parasites was 2.7%, with the most prevalent intestinal helminths and protozoa being *Hookworm spp* (17.6%) and *Entamoeba coli* (52.9%), respectively. Other intestinal parasites observed were *Ascaris lumbricoides, Strongyloides stercoralis, Enta-*

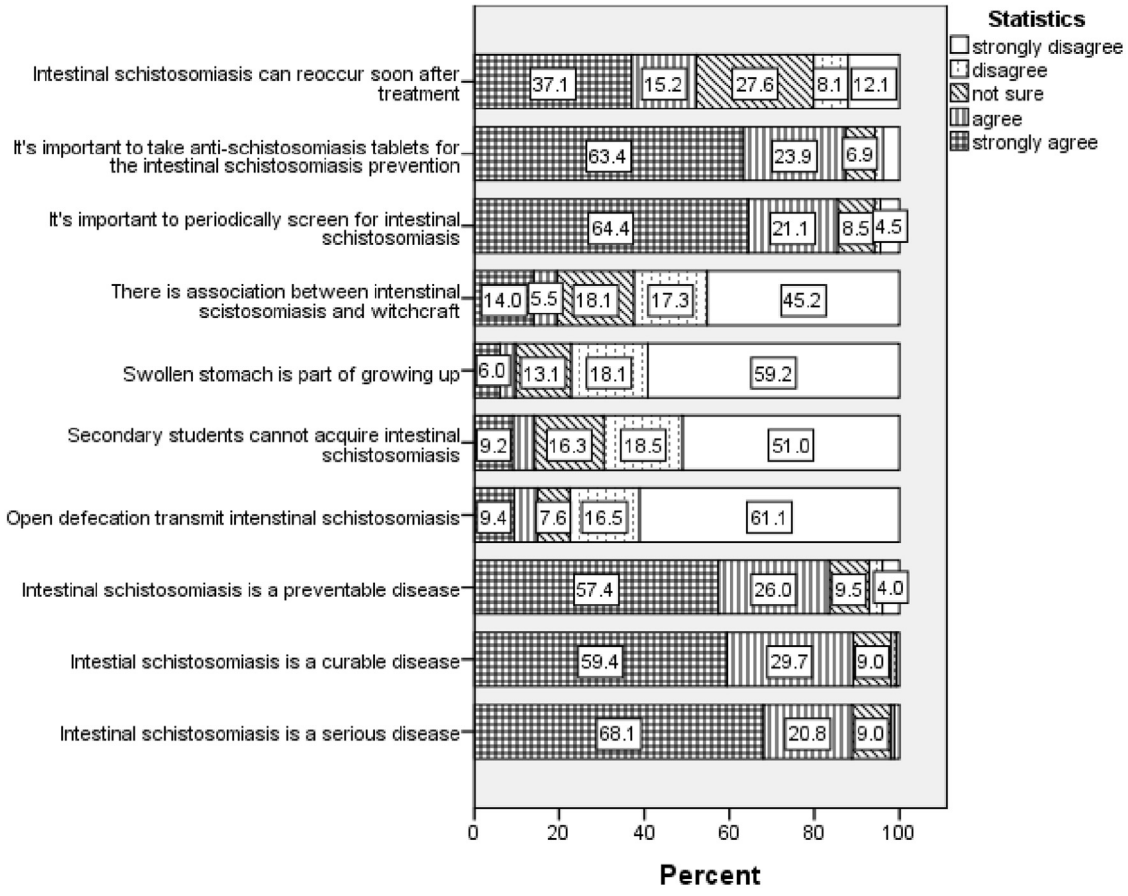

Figure 2. Attitudes on intestinal schistosomiasis among study participants.

Table 4
The knowledge levels according to socio-demographic characteristics of the study participants (n=620).

Variable	Total	Low level of knowledge n (%)	Moderate level of knowledge n (%)	p-value
Sex				
Male	224	48 (21.4)	176 (78.6)	0.598
Female	343	80 (23.3)	263 (76.7)	
Age group (years)				
11-15 years	223	66 (29.6)	157 (70.4)	0.001*
16-20 years	344	62 (18.0)	282 (82.0)	
Class				
Form I	262	74 (28.2)	188 (71.8)	0.010*
Form II	142	28 (19.7)	114 (80.3)	
Form III	118	22 (18.6)	96 (81.4)	
Form IV	45	04 (8.9)	41 (91.1)	
Residency (years)				
≤ 10 years	148	36 (24.3)	112 (75.7)	0.554
11-20 years	419	92 (22.0)	327 (78.0)	
Schools				
Iselamagazi Secondary School	313	72 (23.0)	241 (77.0)	0.712
Mwamalili Secondary School	165	40 (24.2)	125 (75.8)	
Mwawaza Secondary School	56	10 (17.9)	46 (82.1)	
Uzogore Secondary School	33	06 (18.2)	27 (81.8)	
Total	**620**	**129 (22.7)**	**439 (77.3)**	

* Statistically significant (p< 0.05)

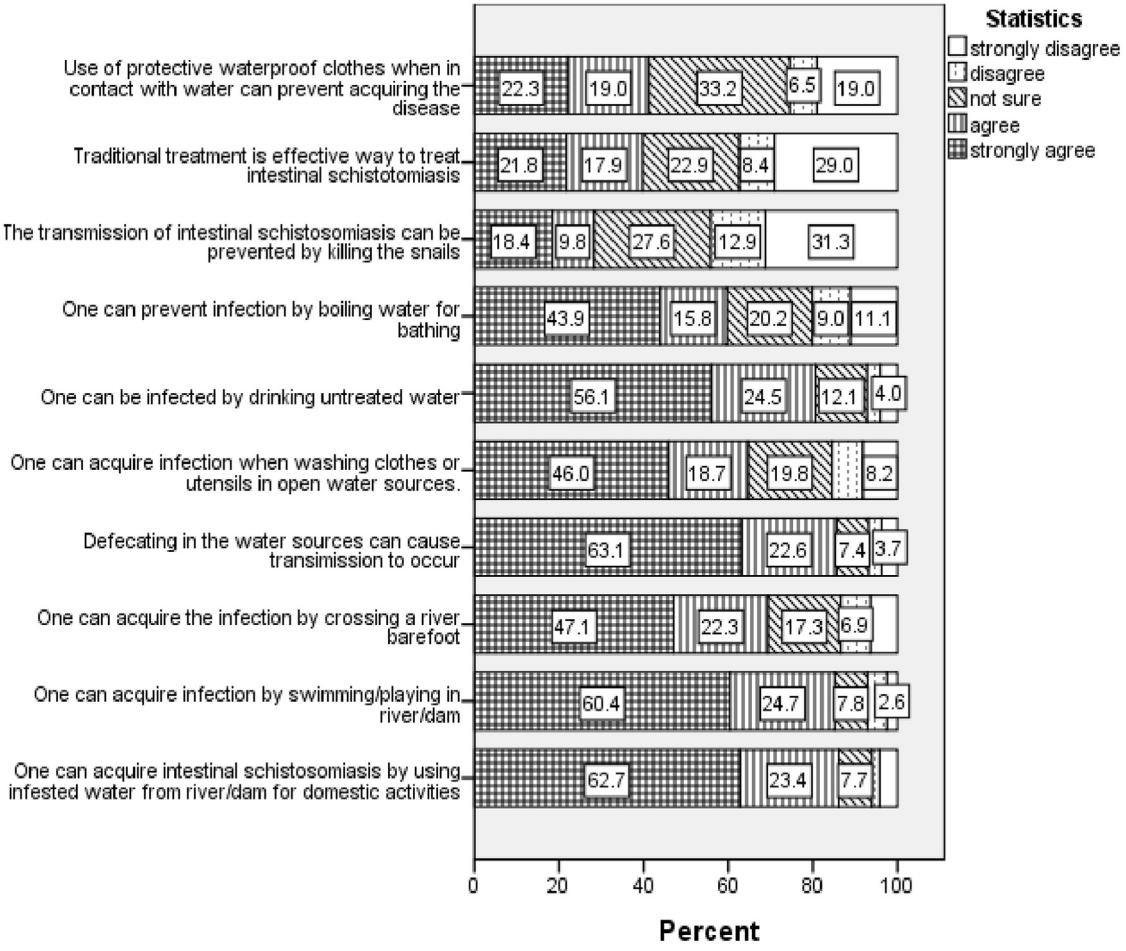

Figure 3. Practices on intestinal schistosomiasis among study participants.

moeba histolytica and *Giardia lamblia*. The observation of other intestinal parasites indicates the fecal contamination of the environment, probably due to inadequate sanitation and unhygienic practices. In Tanzania, *Schistosoma spp* coinfection with soil-transmitted helminths has been reported previously in school children and associated with sanitation, hygienic, environmental and climatic factors that favor multiple transmissions of intestinal parasites [24]. However, the observed prevalence of other intestinal parasites in our study is low compared with observations from Nigeria (36.7%) and Nepal (44.2%) [3,12].

Inadequate knowledge, negative attitudes and inappropriate practices are crucial factors to potentially influence the transmission and acquisition of *S. mansoni* among secondary students. Most study partic-

Table 5
Classification of attitudes and practices according to participants socio-demographic characteristics (n=620).

Socio-demographics	Positive attitudes	Negative attitudes	p-value	Appropriate Practices	Inappropriate practices	p-value
Sex						
Male	134 (53.8)	115 (46.2)	0.861	114 (45.8)	135 (54.2)	0.850
Female	197 (53.1)	174 (46.9)		167 (45.0)	204 (55.0)	
Age group (years)						
11-15 years	118 (48.2)	127 (51.8)	0.035*	111 (45.3)	134 (54.7)	0.995
16-20 years	213 (56.8)	162 (43.2)		170 (45.3)	205 (54.7)	
Class						
Form I	122 (42.8)	163 (57.2)	0.000*	104 (36.5)	181 (63.5)	0.000*
Form II	102 (62.2)	62 (37.8)		80 (48.8)	84 (51.2)	
Form III	76 (61.8)	47 (38.2)		65 (52.8)	58 (47.2)	
Form IV	31 (64.6)	17 (35.4)		32 (66.7)	16 (33.3)	
Residency (years)						
≤ 10 years	90 (55.6)	72 (44.4)		81 (50.0)	81 (50.0)	0.164
11-20 years	241 (52.6)	217 (47.4)		200 (43.7)	258 (56.3)	
Schools						
Iselamagazi Secondary School	195 (57.9)	142 (42.1)	0.035*	194 (57.6)	143 (42.4)	0.000*
Mwamalili Secondary School	86 (50.6)	84 (49.4)		52 (30.6)	118 (69.4)	
Mwawaza Secondary School	31 (40.3)	46 (59.7)		22 (28.6)	55 (71.4)	
Uzogore Secondary School	19 (52.8)	17 (47.2)		13 (36.1)	23 (63.9)	
Total	**331 (53.4)**	**289 (46.6)**		**281 (45.3)**	**339 (54.7)**	

* Statistically significant (p< 0.05)

Table 6
Water, sanitation, and hygiene status of the study participants (n=620).

Variable	n (%)	*S. mansoni* positive	p-value
Visit water source			
Yes	520 (83.9)	12 (2.3)	0.125
No	100 (16.1)	0 (0.0)	
Water source visited			
Pond water	322 (61.9)	11 (3.4)	0.098
River	169 (32.5)	01 (0.6)	
Spring	29 (5.6)	00 (0.0)	
Water source at school			
Tap	620 (100)	12 (1.9)	-
Swimming habit			
Yes	243 (46.7)	09 (3.7)	0.043*
No	277 (53.3)	03 (1.1)	
Open defecation in water sources			
Yes	80 (15.4)	01 (1.2)	0.493
No	440 (84.6)	11 (2.5)	
Habit of shoes wearing			
Yes	296 (56.9)	06 (2.0)	0.624
No	224 (43.1)	06 (2.7)	
Enough toilets at school			
Yes	478 (77.1)	10 (2.1)	0.604
No	142 (22.9)	02 (1.4)	
Performing activities in/near water sources			
Yes	482 (94.9)	12 (2.5)	0.332
No	26 (5.1)	00 (0.0)	
Name of the activities			
Farming	238 (49.4)	03(1.3)	0.105
Fishing	21 (4.4)	02 (9.5)	
Laundry and washing dishes	96 (19.9)	03 (3.1)	
Fetching water	127 (26.3)	04 (3.1)	

* Statistically significant (p< 0.05)

ipants (91.6%) had heard about intestinal schistosomiasis, with schools as the leading source of information (53.7%). Misconceptions about the etiology and modes of transmission were reported in a small but significant number of participants. Misconceptions about the mode of disease acquisition have previously been reported in the same study area, with schoolchildren confusing the mode of soil-transmitted helminth transmission with that of schistosomiasis or other specific aspects of schistosoma pathology [2]. Despite the study participants participating in MDA programs at primary school, only 36.8% correctly knew the use of the anti-schistosomal drug for prevention, reflecting flaws in the health education provided. A low level of knowledge of intestinal schistosomiasis was observed in approximately 22.7% of form I students and students aged 11–15. These findings are similar to a recent study on urogenital schistosomiasis in Northern Tanzania [13]. Nearly half of the study participants (46.6%) had negative attitudes towards the disease aspect, screening, treatment and prevention. In addition, more than half (54.7%) had inappropriate practices, which could lead to intestinal schistosomiasis transmission and acquisition. Hence, the need for health education to promote socio and behavior communication change. The findings are consistent with a systematic review of knowledge, attitudes and practices towards schistosomiasis in sub-Saharan Africa (Sacolo, Chimbari and Kalinda, [23]).

Inadequate supply of clean water, inadequate sanitation and unhygienic practices perpetuate the transmission of intestinal schistosomi-

Table 7
Factors associated with the intestinal schistosomiasis transmission among the study participants (n=620).

Variable	Univariate analysis		Multivariate analysis	
	[a]COR (95% CI)	p-value	[b]AOR (95% CI)	p-value
Sex				
Male	1.		1	
Female	3.9 (3.40-4.63)	0.002	0.34 (0.08-1.38)	0.128
Age group (years)				
11-15 years	1			
16-20 years	0.71 (0.54-7.57)	0.295		
Class				
Form I	1		1	
Form II	1.54 (0.62-17.96)	0.011	4.7 (1.01-12.62)	0.041*
Form III	18.50 (1.04-19.42)	0.00*	21.72 (1.17-33.37)	0.007*
Form IV	0.40 (0.10-1.98)	0.512	1.57 (0.36-6.86)	0.546
Residency (years)				
≤ 10 years	1			
11-20 years	0.67 (0.20-228)	0.528		
Level of knowledge				
Low level	1		1	
Moderate level	4.43 (0.57-35.24)	0.160	5.93 (0.60-19.07)	0.129
Categorization of attitudes				
Negative attitudes	1		1	
Positive attitudes	0.29 (0.07-1.18)	0.084	0.21 (0.05-0.886)	0.034*
Categorization of practices				
Inappropriate practices	1		1	
Appropriate practices	0.88 (0.24-3.20)	0.085	0.05 (0.12-2.14)	0.041*
Visit water source				
Yes	3.80 (3.27-4.47)	0.000	4.31 (3.35-6.27)	0.039*
No	1		1	
Water body visited				
Pond water	1			
River	1.256 (0.54-2.9)	0.598		
Spring	1.0 (0.43-2.4)	0.980		
Swimming habit				
Yes	1		1	
No	0.26 (0.07-1.01)	0.050	0.23 (0.06-0.85)	0.028*
Open defecation in water sources				
Yes	3.15(0.389-25.56)	0.282		
No	1			
A habit of shoes wearing				
Yes	1			
No	1.12 (0.34-3.66)	0.854		
Doing activities in water sources				
Yes	1.5 (1.31-1.67)	0.002	1.70 (1.56-1.97)	0.043*
No	1		1	
Name of the activities				
Farming	1		1	
Fishing	14.56 (0.47-16.30)	0.010	16.34 (0.92-19.34)	0.016*
Laundry and washing dishes	16.80 (0.60-18.56)	0.007	18.58 (0.74-21.53)	0.029*
Fetching water	15.46 (0.27-17.89)	0.010	17.28 (0.47-18.76)	0.010*

* Statistical significance at p<0.05,
[a] *COR* Stands for Crude Odds Ratios,
[b] *AOR* Stands for Adjusted Odds Ratios

asis [11]. All 12 infected participants visited water sources, with 11 reporting ponds as the most frequently visited water sources, probably indicating that ponds are contaminated with viable *S. mansoni* eggs and provide a suitable niche for the survival of the intermediate *Biomphlaria* snails. The results of this study agree with those of other investigations conducted elsewhere [5,10,11]. Nine of the 12 participants who were infected with intestinal schistosomiasis reported having the habit of swimming. The practice of swimming has been associated with the increased risk of transmission and acquisition of intestinal schistosomiasis in endemic countries [10,11].

In multivariate logistic regression, positive attitudes and appropriate practices towards disease transmission, screening, treatment and prevention significantly lowered the odds of *S. mansoni* transmission and acquisition. The odds of infection were higher among participants visiting water sources and carrying out activities in water sources that are probably cercariae-infested, with frequent exposure putting them at risk. This observation has also been reported and emphasized in studies of urogenital and intestinal schistosomiasis from sub-Saharan Africa [2,10,11,13,18,23].

Study limitations

The collection of a single stool sample per study participant may have resulted in an underestimation of intestinal schistosomiasis prevalence. Therefore the prevalence may be higher than observed. In addition, some of the responses in WaSH practices could be unreliable and subject to bias due to a lack of an observation checklist to complement participant responses.

Conclusions and recommendations

The prevalence of intestinal schistosomiasis among the secondary students was 1.9%, indicating ongoing transmission of the disease in the

area, with the possibility of this group serving as the reservoir for *S. mansoni.* The prevalence of other intestinal parasites was 2.7%, with *E. coli* (52.9%) and *Hookworm spps* (17.6%) being the most common intestinal protozoa and helminths, respectively, indicating fecal contamination of the study area. None of the participants had a high level of knowledge about intestinal schistosomiasis, with 46.6% having negative attitudes and more than half (54.7%) having inappropriate practices toward intestinal schistosomiasis. The risk factors for intestinal schistosomiasis were being form II or III students, visiting water sources and carrying out activities in water sources such as fishing, fetching water and laundry. Positive attitudes and appropriate practices towards intestinal schistosomiasis were highly associated with lowering the risk of disease transmission.

Our study demonstrates the need for the Tanzania Ministry of Health, through NTDCP, to include secondary students in the MDA program to reduce the reservoir *of S. mansoni* in the community. The Ministry of Water should ensure an adequate supply of clean and safe water to minimize the number of secondary students visiting water sources which could be cercariae infested. In addition, the Ministry of Water, in collaboration with other stakeholders, should build enough latrines in ratio to the number of students per school to minimize the fecal contamination of the environment. In addition, the NTDCP should design a health education package to improve knowledge about intestinal schistosomiasis and change negative attitudes and inappropriate practices among this group. More epidemiological studies on intestinal schistosomiasis among secondary students are needed to quantify the burden of the disease in this population and plan control strategies. Lastly, precision mapping is required to identify transmission foci efficiently, which may also aid in understanding why some wards are infection free.

Ethical approval and consent to participate

The Muhimbili University of Health and Allied Sciences Institutional Review Board approved the study (Ref. No. DA.282/298/29K/). The Shinyanga MC administrative authorities were approached for permission to conduct a study. Headteachers of the respective schools provided written consent for the secondary students (≤18 years) whose parents verbally consented to their children's participation. Students aged >18 years were requested for their verbal consent before the headteacher provided written consent. Confidentiality was maintained by assigning numbers to study participants rather than names. Information collected was secured and kept confidential. The positive students were referred to a nearby health facility for treatment and management.

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Conflicts of interest

The authors have declared that no competing interests exist.

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Availability of data and materials

The corresponding author will provide the datasets used in/or analyzed during the current work upon reasonable request.

Authors' contributions

LGS, AJS, and VM conceptualized the study; LGS and AJS carried out data collection and processing; VM analyzed data and interpreted the findings; VM, VS, HP, WJ and YEY drafted and revised the manuscript; DT critically reviewed the manuscript. All authors have read and approved the final version of the manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2022.11.012.

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