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Prevalence and predictors of intestinal schistosomiasis among the adult population, and water and sanitation conditions - A community-based cross-section study at Muleba District, Tanzania

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ABSTRACT

INTRODUCTION: Intestinal schistosomiasis is one of the serious public health problems in all age groups and can lead to considerable morbidity and mortality, especially in communities with an inadequate supply of safe water and sanitation services.
This study was conducted to establish the current burden of intestinal schistosomiasis among adults in the Muleba District and assess water and sanitation conditions that might influence the transmission of intestinal schistosomiasis.

METHODS: A community-based cross-sectional study was conducted between July and August 2020. A total of 328 stool samples were collected and processed using formal-ether concentration and Kato-Katz methods. Water and sanitation data were collected using a questionnaire interview conducted among participants. Participants were randomly selected from four villages. Data were analyzed using Statistical Package for the Social Sciences software version 23.

RESULTS: Thirty-six participants (11%) were infected with *Schistosoma mansoni*. The prevalence was higher among households using water from improved sources, houses without sanitation facilities, and participants who do not use sanitation facilities. We found a significantly increased risk of *S. mansoni* infection among participants in households without toilet facilities than those with ventilated improved pit latrine (OR =4.10, p = 0.001).

CONCLUSION: The prevalence of intestinal schistosomiasis infection among the adult population in Muleba indicates a moderate risk of transmission. The type of toilet facility is a significant factor in the perpetuation of *S. mansoni* transmission.

Keywords: Intestinal Schistosomiasis, *Schistosoma Mansoni*, Water, Sanitation, Tanzania

INTRODUCTION

Intestinal schistosomiasis is one of the neglected parasitic diseases that cause significant morbidity and mortality in the tropical and subtropical regions of Africa, Asia, and Latin America. Several species of Schistosoma, including *Schistosoma mansoni (S.mansoni), S. japonicum,*

S. intercalatum, and S. mekongi are responsible for causing intestinal schistosomiasis in different settings. However, *S.mansoni* accounts for more intestinal schistosomiasis cases than the rest of the intestinal Schistosoma species [1]. Globally, 54 million people are infected with *S.mansoni* and 393 million people are at risk of acquiring intestinal schistosomiasis caused by *S.mansoni* [2].

Pre and school-aged children and adults with occupations such as fishing, farming, and irrigation involving contact with infested water are at higher risk of acquiring the infection. However, school-aged children carriers the highest burden of the infection and contribute significantly to the transmission of intestinal schistosomiasis [3]. Chronic intestinal schistosomiasis among the vulnerable population is associated with stunting growth in children, cognitive dysfunction, and hepatosplenic diseases, including splenomegaly and hepatomegaly [4,5]. The transmission of intestinal schistosomiasis is related to several factors such as an inadequate supply of safe water, poor environmental sanitation, unhygienic practices, and low socioeconomic status in poor and rural communities [6–8]. Despite lack of information on the amount of water contact that may be prevented by an adequate supply of safe water and the impact of a reduction in water contact on human schistosomiasis infection rates. Still, it is known that schistosome infections occur during contact with water containing Schistosoma cercariae and that some contact with such water may result from inadequate access to safe water supplies [8].

Intestinal schistosomiasis caused by S.mansoni is endemic in Tanzania with uneven distribution [9]. Prevalence and intensity of S.mansoni in Tanzania range from 40% to 100% in different regions and in communities where farming and fishing are the main sources of income, exposure of adults in infested water becomes inevitable and hence influences the high prevalence of intestinal schistosomiasis in adults compared to school children [9–11]. The global control of intestinal schistosomiasis has been focused on school-aged children through the use of praziquantel, while other vulnerable populations that serve as the reservoir of infection are left out [12].

The previous studies conducted along the Lake Victoria basin found that in the Muleba district, there was a higher prevalence of intestinal schistosomiasis among the adult population compared to school-aged children [13,14]. Evidence indicates the ongoing transmission of intestinal schistosomiasis among the adult population [13]. Hence, there is a need to establish the burden of intestinal schistosomiasis among the adult population and associated risk factors. Therefore, this study was conducted to establish the current burden of intestinal schistosomiasis among adults in the Muleba District and assess water and sanitation conditions that might influence the transmission of intestinal schistosomiasis. The findings will provide information on the current infection status among adults and its association with water and sanitation that will help plan control strategies.

METHODS

Study site: Muleba district is among the six districts of the Kagera Region in Tanzania. The district is bordered to the north by the Bukoba Urban and Bukoba Rural districts, to the south by the Biharamulo District, to the east by Lake Victoria and the west by the Ngara and Karagwe districts. The 2012 Tanzania population and housing census reported a total population of 540,310 (267,858 males and 272,452 females) across an area of 3,518 km2 in the Muleba district [15]. The residents of the Muleba district practice diverse economic activities, key among them being; farming, fishing, livestock rearing and mining. The climatic conditions of the Muleba district are warm and mostly cloudy. Over the years, its temperature varies between 17°C and 26°C that favour the survival of the intermediate snail host (Biomphalaria). Muleba district was selected because of the history of the high prevalence of intestinal schistosomiasis and inadequate water, sanitation and hygiene, which favour transmission of intestinal schistosomiasis [13].

Study design A quantitative cross-section study was conducted from July to August 2020. This sub-study was a part of a large project that aimed to assess the magnitude of geohelminths and associated factors among the adult population in the Muleba District. The study population was males and females in the Muleba District.

Sample size determination and sampling procedure The sample size for this study was calculated from a formula given by Daniel [16]. The study used a prevalence of 18.5% for Schistosoma mansoni among the adult population reported in a previous

study conducted in the area [13], tolerated margin of error of 0.05, standard deviation at 95% CI (1.96) designing effect of 1.5 to calculate the minimum sample size. The estimated sample size for this study was 383 adults from 383 households after adjusting for a non-response rate of 10%. The study participants were sampled through a three-stage cluster sampling technique. The first stage involved a simple random selection of one endemic district whereby the Muleba district was selected. The second stage involved the selection of representative rural wards whereby out of the 11 endemic rural wards, 3 rural wards (Ikuza, Mazinga, and Nyakabango) were randomly selected. The third stage involved the selection of representative villages from the selected rural wards. From each rural ward, 2 villages were selected by simple random sampling. Chakazimbwe and Kasenyi villages were selected from the Ikuza ward, Kimoyomoyo and Mulumo villages were selected from Mazinga ward, and Msalala and Nyakabango villages from Nyakabango ward. The households in each village were selected randomly, and in each selected household, only one member was randomly chosen to participate in this study.

Sample collection and laboratory analysis: Prior to stool collection, study participants were oriented on the stool collection procedures. Then plastic containers with applicator sticks were labeled with identification numbers and distributed to study participants to provide 5g of a fresh stool sample. Stool samples were then collected and immediately fixed with 10% formalin to preserve the eggs of *S. mansoni* and taken to the parasitology laboratory at the Muhimbili University of Health and Allied Sciences for examination. To determine the prevalence and intensity of S.mansoni, the samples were processed and examined for the presence or absence of eggs/ova. Stool samples were processed using formol-ether concentration (FEC) techniques and the positive samples were quantified by Kato-Katz (KK) technique as described in the World Health Organization (WHO) bench aids for the diagnosis of parasitic diseases [17]. The presence of S.mansoni eggs/ova was examined using Olympus CX 31 microscope.

Questionnaire: A structured questionnaire developed in English and then translated to Kiswahili was administered to all adults included in this study by a well-trained interviewer. The questionnaire aimed to collect data on the study participants' socio-demographic characteristics, water, sanitation, and hygiene practices.

Inclusion and exclusion criteria: The inclusion criteria included all adults residing in the Muleba district and who agreed to participate in this study by signing the informed consent. Adults who were sick from schistosomiasis during stool collection, adults who used anthelminthic (praziquantel) within one month before data collection, and those who refused to sign informed consent were excluded from the data collection.

Data analysis: The data was entered and analyzed using Statistical Package for Social Sciences version 22. All categorical variables were summarized to obtain the frequency and proportions. The prevalence of *S. mansoni* was calculated according to sex, age groups, village of residence and occupations. The intensity of S.mansoni was reported as the arithmetic mean of eggs per gram (EPG) and then categorized based on WHO classifications for S.mansoni; (0) negative, (1-99) light infection, (100-399) moderate infection, (>400) heavy infection [18]. The binary logistic regression test was done to determine the association between independent variables (sociodemographic characteristics, water and sanitation variables) and dependent variables (prevalence of S. Manson infectioni). P-value less than 0.05 were considered statistically significant. Ethical clearance was obtained from the Institutional Review Board of the Muhimbili University of Health and Allied Sciences (IRB#: MUHAS-REC-06-2020-309) before the commencement of the study. Permission to conduct the study in Muleba District was requested from the local authorities. Participants were informed about the objectives, procedures, potential risks and benefits of the study, as well as individuals' right to withdraw from participation at any time during the study without negative consequences. Also, written informed consent was sought from respondents after giving them sufficient information. The participants who were found positive for S.mansoni were referred to the nearby health facilities for appropriate treatment.

RESULTS

A total of 328 adults (response rate of 85.6%) from 383 selected households in the six selected villages consented to provide stool samples for intestinal schistosomiasis examination and participation in interviews. The participants' average age was 31.7 (±8.6) years, with the higher percentage (66.8%) falling under the young adults (18-35 years) group.

Table 1: Socio-demographic characteristics of study participants as summarized by villages

Characteristic	Chakazi mbwe n (%)	Kasenyi n (%)	Kimoy omoyo n (%)	Msalala n (%)	Mulumo n (%)	Nyaka bango n (%)	Total n (%)
Gender							
Male	38 (70.4)	27 (49.1%)	27 (49.1%)	32 (58.2)	39 (72.2)	38 (69.1)	201(61.3)
Female	16 (29.6)	28 (50.9)	28 (50.9)	23 (41.8)	15 (27.8)	17 (30.9)	127 (38.7)
Age group							
18-35	35 (64.8)	42 (76.4)	35 (63.6)	38 (69.1)	41 (75.9)	28 (50.9)	219 (66.8)
36-55	19 (35.2)	13 (23.6)	20 (36.4)	17 (30.9)	13 (24.1)	27 (49.1)	109 (33.2)
Education							
Primary & below	36 (66.7)	34 (61.8)	32 (58.2)	33 (60.0)	33 (61.1)	33 (60.0)	201 (61.3)
Secondary & above	18 (33.3)	21 (38.1)	23 (41.8)	22 (40.0)	21 (38.9)	22(40.0)	127(38.7)
Occupation							
Farmer	17 (31.5)	18 (32.7)	24 (43.6)	34 (61.8)	6 (11.1)	21 (38.2)	120 (36.6)
Business	2 (3.7)	1 (1.8)	7 (12.7)	5 (9.1)	1 (1.9)	2 (3.6)	18 (5.5)
Fisherman	25 (46.3)	30 (54.5)	20 (36.4)	14 (25.5)	32 (59.3)	26 (47.3)	147 (44.8)
Casual laborer	10 (18.5)	6 (10.9)	4 (7.3)	2 (3.6)	15 (27.8)	6 (10.9)	43 (13.1)

Most of the participants were male (61.3%), fishermen (36.6%), and attained primary school education level (61%) (Table 1). Selected villages were either in the islands or located along the shore of Lake Victoria.

The majority of the participants (75%) have reported always having water available, with more than half of participants (59.1%) using unimproved water sources (unprotected dug wells, unprotected springs, and surface water). Also, the majority (83.5%) reported spending less than 30 minutes from their households to the water sources, queue for water collection, and return to their households. Of 328 households surveyed, 293 (89.3%) had toilet facilities. However, only (72.9%) were using the toilets (Table 2).

The overall prevalence of intestinal schistosomiasis (Schistosoma mansoni) was 11%, as determined by FEC method. The prevalence was higher among participants from households without toilets, with rare water availability and taking more than 30 minutes to fetch water. Also, the prevalence was higher in participants from households fetching water from improved sources and not using toilets (Table 3).

Based on KK results of the FEC positive samples,

the geometrical mean intensity of infection was 20.6 (95% Cl: 15.5 – 29.7) EPG of stool. Only one participant had a heavy intensity of infection. The participant with a heavy intensity of infection reported that water is always available in his household, but it's from an unimproved source. Also, reported to live in households with a toilet facility but not using it (Table 3). Participants from households without toilet facilities had a four times higher risk of *S. mansoni* infection than those from households with VIP toilet facilities (OR = 4.10, p = 0.001) (Table 3).

DISCUSSION

Globally, schistosomiasis control is solely based on providing praziquantel PC to school-aged children (SAC). SAC are targeted because they are considered as a group at higher risk of schistosomiasis infection [19]. Despite more than 15 years of praziquantel distribution to the vulnerable population who are known to be the source of schistosomiasis transmission to the communities still, there is ongoing transmission even to the adult population, which indicates the disease is still a public health problem in the Kagera region (where Muleba district is located)

Table 2: Water and sanitation condition of study communities as summarized by villages

Characteristic	Chakazi-mbwe n (%)	Kasenyi n (%)	Kimoyo-moyo n (%)	Msalala n (%)	Mulumo n (%)	Nyaka-bango n (%)	Total n (%)
Water availability							
Always	41 (75.9)	42(76.4)	38 (69.1)	40 (72.7)	41 (75.9)	44 (80.0)	246 (75.0)
Rarely	13 (24.1)	13 (23.6)	17 (30.9)	15 (27.3)	13 (24.1)	11 (20.0)	82 (25.0)
Source of water							
Unimproved	34 (63.0)	29 (52.7)	37 (67.3)	26 (47.3)	33 (61.1)	35 (63.6)	194 (59.1)
Improved	20 (37.0)	26 (47.3)	18 (32.7)	29 (52.7)	21 (38.9)	20 (36.4)	134 (40.9)
Time to fetch water							
Less than 30 minutes	46 (85.2)	48 (87.3)	45 (81.8)	49 (89.1)	44 (81.5)	42 (76.4)	274 (83.5)
More than 30 minutes	8 (14.8)	7 (12.7)	10 (18.2)	6 (10.9)	10 (18.5)	13 (23.6)	54 (16.5)
Type of toilet							
Pit latrine	43 (79.6)	51 (92.7)	47 (85.5)	50 (90.9)	38 (70.4)	52 (94.5)	281 (85.7)
VIP	6 (11.1)	0 (0.0)	0 (0.0)	0 (0.0)	6 (11.1)	0 (0.0)	12 (3.6)
No toilet	5 (9.3)	4 (7.3)	8 (14.5)	5 (9.1)	10 (18.5)	3 (5.5)	35 (10.7)
Toilet use							
Yes	38 (70.4)	44 (80.0)	41 (74.5)	36 (65.5)	42 (77.8)	38 (69.1)	239 (72.9)
No	16 (29.6)	11 (20.0)	14 (25.5)	19 (34.5)	12 (22.2)	17 (30.9)	89 (27.1)

[20]. The findings of our study are in line with the results of the previous study conducted more than five years ago, suggesting consistent Schistosoma mansoni transmission in Muleba [20]. The recorded prevalence indicates that the populations in the studied areas are at moderate risk of acquiring intestinal schistosomiasis [19]. The prevalence of S.mansoni infection among the adult population could be attributed to occupational exposure to schistosomiasis transmission risk factors. Many adult people in the studied areas were farmers and fishermen at high risk of schistosomiasis infection. They are at a higher chance of being exposed to contaminated water and poor sanitation condition. The majority of infected participants had a light intensity of infection. The light intensity of infection indicates a low burden (morbidity and mortality) of infection [19].

Provision of PC was observed to reduce the rate of schistosomiasis prevalence in the short term and does not protect against subsequent infection (reinfection), especially in intestinal schistosomiasis [19,21]. Therefore, relying on PC and ignoring other control measures such as water, sanitation, health education, and snail control was insufficient to interrupt schistosomiasis transmission. Unimproved water sources and sanitation facilities are important factors contributing to the persistent transmission of intestinal schistosomiasis [7]. Water availability and access in the six villages is not a problem, but the majority are taking water from unimproved sources. However, our findings showed no association between the water source and the prevalence of intestinal schistosomiasis. A similar result was reported in a study conducted in Kenya [22]. The prevalence of intestinal schistosomiasis is higher among participants in areas with difficult access to water (rare availability of water and using more than 30 minutes to fetch water) (Table 3). The higher prevalence could be because many people with difficult access to water tend to do most of the water-related chores nearby water sources to reduce the water fetching workload (reduce the number of trips to carry water and carry water only for drinking and cooking). Water-related chores

Table 3: Association between intestinal schistosomiasis *(Schistosoma mansoni)* infection with socio-demographic characteristics, water and sanitation condition

Characteristic	Prevalence by FEC technique		Binary logistic regression	
	Tested	Positive (%)	Odd ratio (95% CI)	p-value
Gender				
Male	201	22 (10.9)	Ref	
Female	127	14(11.0)	1.01 (0.50 − 2.05)	0.980
Age group				
18-35	219	23 (10.5)	Ref	
36-55	109	13 (11.9)	1.15 (0.56 − 2.38)	0.690
Education				
Primary and less	201	25 (12.4)	Ref	
Secondary and above	127	11 (8.6)	0.67 (0.32 − 1.41)	0.290
Occupation				
Farmers	120	12 (10.0)	Ref	
Business	18	3 (16.7)	1.80 (0.46 − 7.12)	0.400
Fisherman	147	16 (10.9)	1.10 (0.50 − 2.42)	0.810
Casual laborers	43	5 (11.6)	1.18 (0.39 − 3.58)	0.770
Village				
Nyakabango	55	3 (5.5)	Ref	
Chakazimbwe	54	3 (5.6)	1.02 (0.20 − 5.29)	0.980
Kasenyi	56	9 (16.4)	3.39 (0.87 − 13.29)	0.080
Kimoyomo	55	7 (12.7)	2.53 (0.62 − 10.34)	0.200
Msalala	55	5 (9.1)	1.73 (0.39 − 7.64)	0.470
Mulumo	54	9 (16.7)	3.47 (0.88-13 .39)	0.070
Water availability				
Always	246	25 (10.2)	Ref	
Rarely	82	11 (13.4)	1.43 (0.60 − 3.40)	0.420
Source of water				
Unimproved	194	18 (9.3)	Ref	
Improved	134	18 (13.4)	1.52 (0.76 − 3.04)	0.240
Time to fetch water				
< 30 minutes	274	30 (10.9)	Ref	
≥ 30 minutes	54	6 (11.1)	1.02 (0.40 − 2.58)	0.970
Type of toilet				
VIP	12	1 (8.3)	Ref	
Pit latrine	281	25 (8.9)	0.93 (0.11 − 7.51)	0.940
No toilet	35	10 (28.6)	4.10 (1.77 − 9.49)	0.001
Toilet use				
No	89	9 (10.1)	Ref	
Yes	239	27 (11.3)	1.21 (0.57 − 2.57)	0.630

that could result in fecal contamination of water sources and expose people to contaminated water include washing soiled clothes, open defecation (contaminate water source through fecal washing during rain/flooding), and hygienic bathing [8]. Surprisingly, we noted the higher prevalence of *S. mansoni* infections among households using water from improved sources. However, this is possible as the transmission does not occur within the house rather than outside. Therefore, people may get infected during their socio-economic activities outside their homes [8].

We found the type of toilet facility to be a significant factor in intestinal schistosomiasis transmission. Participants from households without toilet facilities had a significantly higher prevalence of intestinal schistosomiasis than households with toilet facilities. In contrast to the findings recorded in Kenya [22], our results showed that the prevalence of intestinal schistosomiasis is significantly associated with the household's type of toilet facility (Table 3). Despite the availability of toilet facilities in most visited households (pit latrines and VIP), most interviewed adults responded that they do not use toilets. Most non-toilet users preferred the use of bushes (open defecation). A study conducted in India reported that the main reasons people do not use toilets are a preference for open defecation and lack of privacy (feel shy). Using a sanitation facility (toilet) was considered inconvenient [23]. It was shown elsewhere that possibility of open defecation in farming communities is high due to the lack of sanitation facilities in the farms [22]. Results from stool examination showed a slightly higher prevalence of *S. mansoni* among participants who do not use toilets than those using toilets for defecation. It could be because most people practicing open defecation preferred to do it in bushes surrounding water sources as these areas offer both privacy and water for hygienic bathing [8]. Defecating nearby water bodies and hygienic bathing in water bodies may contaminate the water with feaces containing Schistosomes eggs resulting in the perpetuation of schistosome transmission.

CONCLUSION

This study showed that the adult population in Muleba had a higher prevalence of *S. mansoni* and continued to act as a reservoir of the infection. More than 75% of Schistosoma infected participants are farmers and fishermen, indicating occupational exposure. Therefore, adults and occupationally exposed populations have to be considered for inclusion in intervention campaigns. The majority of water sources in the studied areas are unimproved ones. Most of the surveyed households have improved sanitation facilities. Participants from the few houses without sanitation facilities bear the higher burden of the disease. Despite the high coverage of sanitation facilities, people do not prefer to use them. The prevalence of infection is higher among non-toilet users. It gives an alert for a call on behavioral change intervention.

Author Contributions

Conceptualization: Monica Shabani. Data curation: Monica Shabani, Abdallah Zacharia, Vivian Mushi, Mary Joseph, Clemence Kinabo, Twilumba Makene. **Formal analysis:** Abdallah Zacharia, Vivian Mushi. **Methodology:** Monica Shabani, Abdallah Zacharia, Vivian Mushi. Writing – original draft: Abdallah Zacharia, Vivian Mushi, Mary Joseph, Clemence Kinabo, Twilumba Makene, Monica Shabani.

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