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ABSTRACT

***Background*: Schistosomiasis is the most prevalent helminthic infection in sub-Saharan Africa. School age children have the highest burden. Chronic schistosome infections in children can have irreversible effects lasting throughout adulthood.**
Objective: To determine the prevalence, intensity and distribution of urogenital and intestinal schistosomiasis among primary school children in Migori County, Kenya.
***Design*: Descriptive cross-sectional study.**
***Setting*: Primary schools in Migori County, Kenya.**
***Subjects*: Children aged seven to fourteen years.**
***Results*: We enrolled 1,784 children with the ratio of female to males being 1:1. Their mean age was 11.4 years (standard deviation ± 1.6). The overall prevalence of infection was 26%, with urogenital and intestinal schistosomiasis being found in 9% and 20% of children, respectively. A trend of increasing prevalence with increasing age of children was observed. Boys had a 50% higher risk of being infected with schistosomiasis when compared to girls (adjusted odds ratio 1.5, 95% confidence interval 1.2-1.9). Intensities of schistosome infections did not vary significantly across gender and age. Nyatike Constituency had the highest prevalence of schistosomiasis (54%).Prevalence in schools ranged from 1.7 to 89%. Seven schools (23%) had a schistosomiasis prevalence of at least 50% while 12 (39%) schools had schistosomiasis prevalence of between 10 and 50%.**
***Conclusion*: Our study showed that schistosomiasis is endemic in the study area and represents a significant public health problem among school children. The area should be prioritised for interventions including mass deworming, public health education and sanitation improvement.**

INTRODUCTION

Schistosomiasis represents a serious but under-recognised disease burden for many developing countries. Schistosomiasis and other chronic parasitic diseases are key contributors to the perpetuation of disability and poverty, especially in populations living in resource limited settings (1). Globally, it is estimated that 207 million people suffer from schistosomiasis with the majority (170 million) residing in sub-Saharan Africa (SSA)(2). According to Kenya's Neglected Tropical Diseases Programme, Schistosomiasis is endemic in 56 sub-counties. More than six million people in Kenya have previously been reported as infected with urinary and/or intestinal schistosomiasis (3).

Human schistosomiasis is caused by trematode flukes of the genus *Schistosoma*. The highest burden of schistosomiasis is found among school-age children, aged five to fourteen years (4). Schistosome infections have been linked with anti-parasitic inflammation, risk of anaemia, growth stunting and malnutrition (5). Chronic infection can lead to permanent impairment of cognitive development, and reduced work capacity (6).The situation is further exacerbated by concurrent infections involving both urogenital and intestinal schistosomiasis (7**.** Studies indicate that such overlapping infections can be synergistic. Thus, chronic schistosomiasis co-infections can potentially modify vulnerability to other diseases such as malaria and hepatitis C virus, among dually infected individuals (6,8). Additionally, the presence of chronic schistosomiasis has been shown to accelerate the process of HIV replication, the process of immunosuppression and progression to active TB in co-infected subjects (6).

The risk of infection with schistosomiasis is strongly associated with poverty, which favours exposure to contaminated fresh water, the habitat of the intermediate host snail species. This risk is significantly increased with daily use of unprotected water bodies such as streams and lakes for activities such as bathing, laundering, swimming and agriculture (9). Schistosomiasis infections are further increased with the lack of sanitary facilities that protect water bodies from human waste contamination which remains a key challenge in developing contexts (10).

In Kenya, two species of schistosomes are responsible for human schistosomiasis; *Schistosoma haematobium*, which infects the urogenital tract, and *Schistosoma mansoni,* which infects the intestinal tract. The highest burden of schistosomiasis is frequently reported among communities living around Lake Victoria (11). Recent studies have reported an increased risk of schistosomiasis infection compared to the early 1970s, when the prevalence was less than 50% among school children along the shores of Lake Victoria (schistomiasis endemic zone) (11). Migori County lies within this schistosomiasis endemic zone.

Recent, anecdotal reports from teachers in local schools in Migori indicated that symptoms of urogenital schistosomiasis, such as passing bloody urine (haematuria) have been observed among school children, suggesting potentially high endemicity. The prevalence of urogenital and intestinal schistosomiasis in the population residing in this county remains largely undocumented and to our knowledge, there are no published reports on the burden of schistosomiasis in Migori County.

Determining schistosomiasis prevalence and intensity in areas where the disease transmission is suspected is an important starting point for planning, surveillance and implementation of prevention and control of interventions. Furthermore, understanding how transmission varies within small spatial scales will likely enhance disease prevention and control efforts by targeting high risk groups and shaping future intervention strategies. This is particularly important considering that current schistosomiasis control programmes aim at suppressing morbidity using mass drug administration with praziquantel (12).

Orally administered praziquantelis affordable, efficacious and safe for large-scale treatment interventions (13). The benefits of such a strategy can be optimised by precise geographical identification of transmission areas through quantification of disease prevalence and infection intensities.The World Health Organisation (WHO) recommends that large-scale deworming programmes are preceded by detailed geographical assessments of schistosomiasis, to target use of praziquantelin areas of high need, improve efficacy and maximize resources (14).

This study therefore aims to describe the prevalence, infection intensity, geographical distribution as well as the co-endemicity of urogenital and intestinal schistosomiasis among primary school children in Migori County, Kenya.

MATERIALS AND METHODS

Study design: A descriptive cross-sectional study, using previously collected programmatic data. The STROBE guidelines were used to ensure the quality of reporting in this study (15).

General setting: Kenya is located on the eastern part of Africa and had an estimated population of over 46 million in 2015. Children (five to fourteen years) account for 28% of the total country's population (16). Since 2013, the country has been divided into 47 semi-autonomous counties.

Specific setting: Study data were collected in Migori County, Kenya, in October 2014. The county is bordered by the world's second largest fresh water lake, Lake Victoria. The county has a population of 917,170 with 43% of the population living below the poverty line (17). Migori County has eight constituencies: Suna East, Suna West, Uriri, Awendo, Rongo, Nyatike, Kuria East and Kuria West. In 2014, there were 788 primary schools in the county with a total enrolment of 307,931 children (18).

Study sites and study population: The study sites were 31 primary schools in Migori County. The study population comprised of children aged 7-14 years enrolled in the selected public and private primary schools. Only assenting children whose parents/caregivers consented to their participation were included in the study. Menstruating females (excluding *S. haematobium* sampling)were excluded.

Sample size: The minimum required sample size was determined based on WHO guidelines, whereby in cases of varying climatic and geographical zones, a minimum sample of 250 individuals, selected from each zone,is considered adequate for evaluation of prevalence and intensity of infections (19).

Selection of schools was purposive and was informed and guided by previous knowledge on the areas where transmission is known, suspected or more likely (proximity to lakes, streams, water bodies). In particular, schools where complaints of haematuria had been reported were included in the study. The selection of schools also considered geographical distribution of schools in order to ensure proper representation.

From each school, selection of children was done using computer-generated randomisation. Ten students were selected from each class with stratification being done by gender to ensure a ratio of 1:1. A minimum of fifty children per school were recruited.

Variables and data source: The outcome variables were the presence or absence of schistosome and intensity of infections. Independent variables included age, gender, locality and school. Study data were retrieved from the NTDU database together with geo-coordinates of the schools. Geo-referenced maps of the study area including the water bodies were retrieved from an online database (21).

Data collection procedures: Data on selected demographic characteristics (age and gender) were recorded as samples were being collected.Stool samples were processed by Kato Katz technique (20). Duplicate slides of the resultant thick smears were observed microscopically and number of species-specific eggs observed were recorded.Urine samples were collected between 10:00 and 14:00 hours and agitated to ensure adequate dispersal of eggs. Ten mL of urine was passed through Nucleopore-H filters. The filters were mounted on a slide and examined microscopically for the presence of schistosome eggs. The number of species-specific eggs observedwere recorded.For quality assurance purposes, 10% of the slides were re-examined by an independent expert microscopist. Demographic and laboratory data were later encoded into the Neglected Tropical Diseases Unit's (NTDU) database.

Analysis and statistics: Data were exported into EpiData software (version 2.2.2.183) for analysis, (EpiData Association, Odense, Denmark). Intensity of schistosome infections were summarised as geometric mean egg counts. Mapping of the burden of schistosomiasis in schools was done using the ArcGIS 10.3 (ESRI, Redlands, USA).

Data were analysed descriptively, a chi-square test was used to establish associations between the intensity of infection with age group and gender respectively. TheMann-Whitney U test was used to compare the median egg counts between males and females, reported with interquartile range (IQR). Binary logistic regression was used to estimate the adjusted odds ratios (AOR) and their 95% confidence intervals (CI) for factors associated with schistosomiasis infection. Two-tailed p-values of < 0.05 were considered statistically significant.

Ethics consideration: This study utilised de-identified, secured data with permission from the NTDU, Ministry of Health. Assents and informed consents were provided by the children and their parents/caregivers, respectively. An annual mass treatment was conducted by the National School Based Deworming Programme and the NTDU, following completion of the survey. The study was reviewed and approved by the ethics boards of Moi University/MTRH (Eldoret, Kenya) and Médecins Sans Frontières (Geneva, Switzerland).

RESULTS

A total of 1,784 children were enrolled in the survey with 886 (50%) being males.The mean age was 11.4 years (standard deviation (SD), 1.6) (Table 1). Most study participants were from either Kuria West (33%), Nyatike (29%) or Suna West (20%) constituencies.

Table 1
Demographic characteristics of school children enrolled in the Schistosomiasis survey in Migori County, Kenya

Characteristic (N=1784)	n	Percentage (%)
Gender		
Male	886	50
Female	898	50
Age (years)		
7 - 8	64	4
9 - 10	455	26
11 - 12	792	44
13 - 14	473	27
Constituency		
Kuria West	580	33
Nyatike	511	29
Suna West	351	20
Suna East	169	10
Rongo	58	3
Uriri	58	3

Of the 1,719 children who provided both foecal and urine samples, 452 (26%) were positive for schistosomiasis. Intestinal schistosomiasis was found in 339 (20%) children of those whose stool samples were examined. Additionally, 158 (9%) childrenof those whose urine samples were examined were positive for urogenital schistosomiasis. Co-infection with urogenital and intestinal schistosomiasis was found in 38 (2%) children providing both urine and stool samples (Table 2).

Table 3 shows prevalence of schistosomiasis by constituency among children enrolled in the survey. Nyatike constituency had the highest prevalence of schistosomiasis (54%) of which 16% was urogenital and 42% intestinal schistosomiasis (42%).Kuria West had the lowest prevalence of schistosomiasis of 5% Children who were diagnosed with either or both forms of schistosomiasis were significantly older than their counterparts who were reported to be free of schistosome infections (mean age ± sd: 11.6±0.07 and 11.4±0.04 years, respectively, p=0.03). An increase in age by one year was associated with 10% increment in the risk of having schistosomiasis, (AOR=1.1, CI=1.0-1.2, p=0.03). Maleshad a 50% higher chanceof being infected when compared to females ((AOR=1.5, CI=1.2-1.9, p=0.002). Compared to residing in Kuria West, children from Nyatike, Rongo, Awendo and Uriri constituencies were more likely to have schistosomiasis.

Figure1presentstheprevalenceofschistosomiasis disaggregated by age of enrolled school children. Overall, shistosomiasis prevalence increased with increasing age of children. Across all ages, prevalence of intestinal schistosomiasis was higher than that of urogenital schistosomiasis. No cases of urogenital schistosome infections were reported among children aged seven and eight years.

Intensities of *S. haematobium* and *S. mansoni* infections: Gender comparisionsof intensities of *S. mansoni* infections were not significantly different (p=0.7) nor were theirvariations by age group (Table 5).

The median distribution of the intensity of *S. haematobium* infections was the same across gender: 10 (IQR=2-37) and 18 (IQR=3-45) eggs per 10 ml of urine for girls and boys respectively, (p=0.2). In addition, the prevalence of light and heavy intensities of infections were not different when assessed by age and gender (Table 6).

Table 2

Prevalence of schistosomiasis among school children enrolled in the Schistosomiasis survey in Migori County, Kenya

Infection	Samples collected	Positive samples	% (95%CI)
Schistosomiasisa	1719	452	26.3 (24.2-28.4)
Intestinal schistosomiasis	1735	339	19.5 (17.6 - 21.4)
Urogenital schistosomiasis*	1768	158	8.9 (7.6 - 10.2)
Coinfection (Intestinal and urogenital schistosomiasis)	1719	38	2.2 (1.5 - 2.9)

[a]Either intestinal schistosomiasis or urogenital schistosomiasis or both; *Based on urine examination; CI = Confidence interval.

Table 3 shows prevalence of schistosomiasis by constituency among children enrolled in the survey. Nyatike constituency had the highest prevalence of schistosomiasis (54%) of which 16% was urogenital and 42% intestinal schistosomiasis(42%). Kuria West had the lowest prevalence of schistosomiasis of 5%.

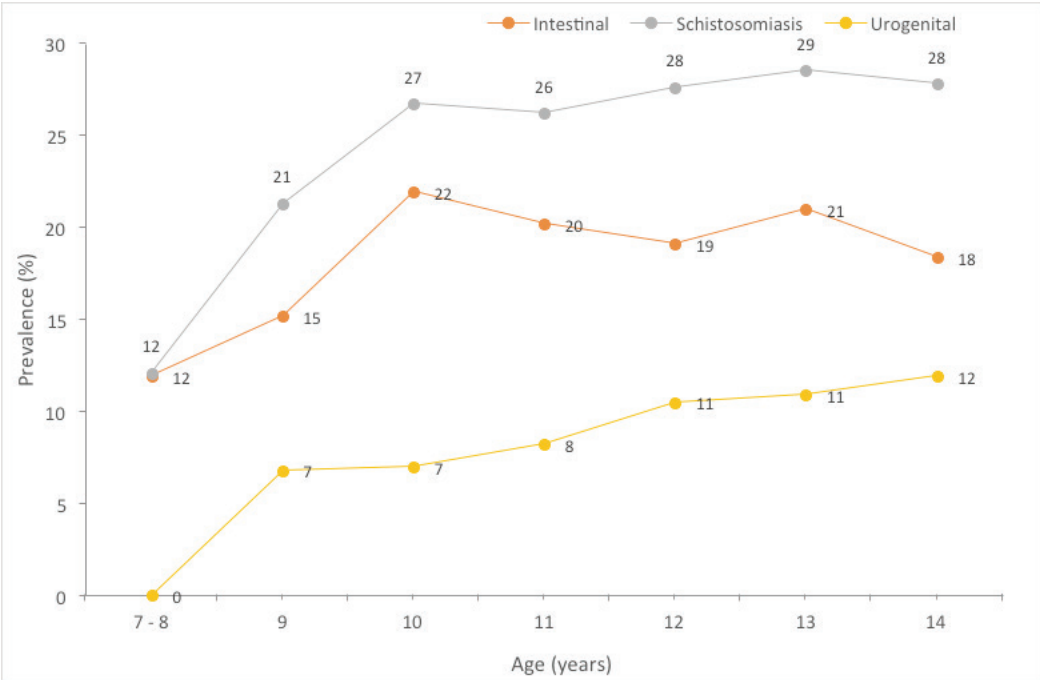
Table 3

Prevalence of schistosomiasis, by constituency, among school children enrolled in the Schistosomiasis survey in Migori County, Kenya

Constituency	Schistosomiasis					
	Overall*		Intestinal		Urogenital	
	N	n (%)	N	n (%)	N	n (%)
Nyatike	557	265(54)	492	208(42)	511	84(16)
Rongo	127	10(17)	330	63(19)	58	1(2)
Awendo	26	13(23)	56	10(18)	57	3(5)
Uriri	42	20(35)	58	18(31)	58	4(7)
Kuria West	58	29(5)	574	18(3)	580	11(2)
Suna East	25	12(8)	167	12(7)	153	1(1)

*Urogenital and/or Intestinal schistosomiasis

Figure 1
Prevalence of schistosomiasis by age of school children enrolled in the Schistosomiasis survey in Migori County, Kenya



Children who were diagnosed with either or both forms of schistosomiasis were significantly older than their counterparts who were reported to be free of schistosome infections (mean age ± sd: 11.6±0.07 and 11.4±0.04 years, respectively, p=0.03). An increase in age by one year was associated with 10% increment in the risk of having schistosomiasis, (AOR=1.1, CI=1.0-1.2, p=0.03). Males had a 50% higher chance of being infected when compared to females (AOR=1.5, CI=1.2-1.9, p=0.002). Compared to residing in Kuria West, children from Nyatike, Rongo, Awendo and Uriri constituencies were more likely to have schistosomiasis.

Table 4
Factors associated with schistosomiasis in school children enrolled in the Schistosomiasis survey in Migori County, Kenya

Characteristic	n (%)	OR(95% CI)	P-value	AOR (95% CI)	P-value
Age (years)				1.1(1.0-1.2)	0.03
Gender					
Female	197(23)	Reference		Reference	
Male	255(29)	1.4(1.1-1.7)	0.004	1.5(1.2-1.9)	0.002
Constituency					
Kuria West	29(5)	Reference		Reference	
Nyatike	265(54)	21.9(14.5-33.2)	<0.001	22.6(14.9-34.2)	<0.001
Rongo	10(17)	3.9(1.8-8.5)	<0.001	4.0(1.8-8.7)	0.001
Awendo	13(23)	5.7(2.8-11.7)	<0.001	5.3(2.6-11.1)	<0.001
Uriri	20(35)	9.9(5.1-19.1)	<0.001	10.2(5.3-19.7)	<0.001
Suna East	12(8)	1.6(0.8-3.3)	0.2	1.6(0.8-3.2)	0.2

OR = Odds ratio; AOR = Adjusted odds ratio; CI = Confidence intervals

Table 5

Intensity of S. mansoni by gender and age among infected school children enrolled in the Schistosomiasis survey in Migori County, Kenya

Characteristic	Total	Intensity of infection, n (%) Light (1-99epg*)	Moderate (100-399epg*)	Heavy (≥400epg*)	P-value£
Gender					
Male	184	104(57)	56(30)	24(13)	0.8
Female	155	86(56)	52(34)	17(11)	
Overall	339	190(56)	108(32)	41(12)	
Age (years)					
7 - 8	8	3(38)	3(38)	2(25)	0.6
9 - 10	86	46(54)	29(35)	11(13)	
11 - 12	152	92(61)	42(28)	18(12)	
13-14	93	49(53)	34(37)	10(11)	
Overall	339	190(56)	108(32)	41(12)	

*epg = eggs per gram of stool; £based on chi square test

Table 6

Intensity of S. haematobium stratified by gender and age among infected school children enrolled in the Schistosomiasis survey in Migori County, Kenya

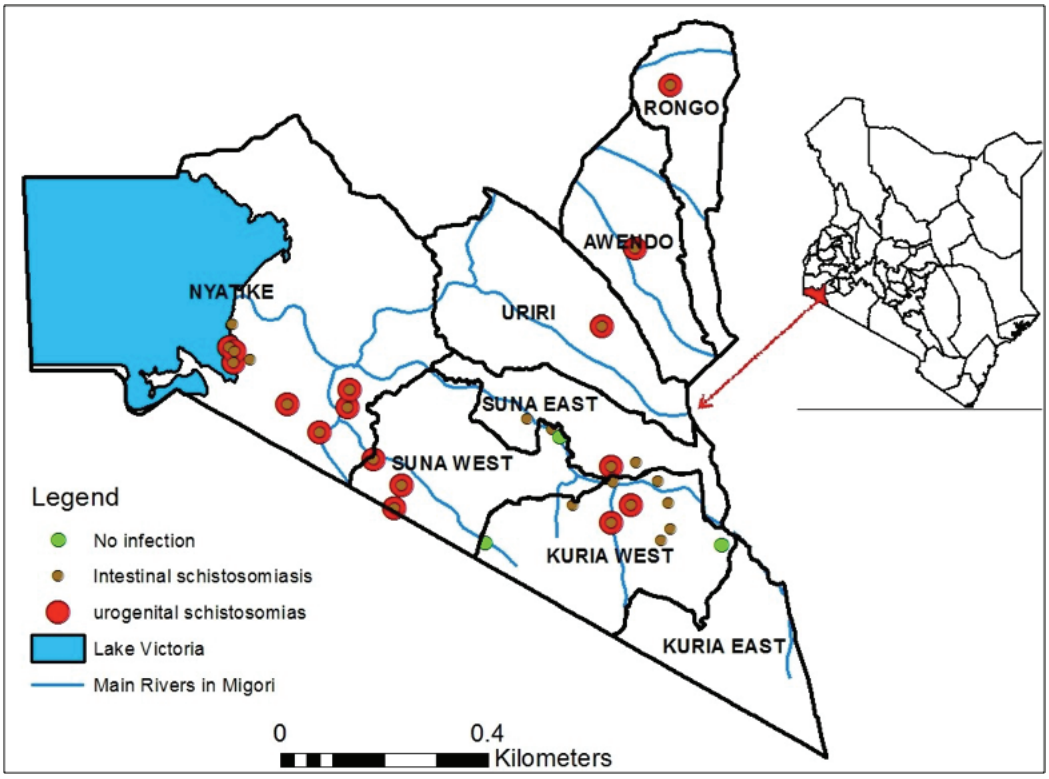
Characteristic	Infection intensity Light* n (%)	Heavy† n (%)	P-value£
Gender			
Male	70 (77)	21 (23)	0.3
Female	54 (81)	13 (19)	
Age (years)			
7 - 8	0 (0)	0 (0)	0.1
9 - 10	28 (90)	3 (10)	
11 - 12	58 (78)	16 (22)	
13 - 14	38 (72)	15 (28)	*1–49

eggs/10 ml urine; †≥50 eggs/10 ml urine; £based on chi-squared test

Spatial distribution of schistosomiasis: Figure 2 shows the distribution of schistosome infections in the sampled schools. In all the sampled constituencies, except Suna East, co-endemicity of urogenital and intestinal schistosomiasis was observed. No cases of schistosome infections were reported in three of the 31 schools (9.7%) that participated in the study. The prevalence of schistosomiasis in the affected schools ranged between 1.7-88.9%. Seven schools (23%) had a schistosomiasis prevalence of 50% or more, 12 (39%)

between 10% and 50% while the prevalence of schistosomiasis in 9 (2%) of schools was less than 10%.

Figure 2
Distribution of schistosome infections among school children enrolled in the Schistosomiasis survey in Migori County, Kenya



DISCUSSION

Our survey documented a substantial burden of schistosomiasis in the study area. One in every four children suffered from schistosomiasis,with boys and older children being at a higher risk. The overall prevalence of schistosomiasis was higher than 18% reported in a survey conducted in rural villages of Kwale district, coastal Kenya (22). The difference could be due to the fact that the latter was a community-based study while our study was school-based. Additionally, unlike in our study area, school age children had been receiving treatment under the National School Based Deworming Programme.

We also observed that urogenital schistosomiasis was less common, with a tenth of all children being infected compared to one in five that had intestinal schistosomiasis. Compared to our study, a Malawian study found higher prevalences where overall schistosomiasis affected half the participants. Contrary to our findings, urogenital schistosomiasis was prevalent in 51% of the population in the area whilst intestinal schistosomiasis was found in only 10% (23). The Malawian study was community-based and sampled households within five kilometers of water reservoirs. Considering the focal nature of the distribution of the disease, this may partly explain the dissimilarities. Another possible explanation were the disparities in environmental conditions between the two study areas, which may have influenced distribution of snail vectors.

The prevalence of intestinal schistosomiasis in our study was three-fold less than what was reported in a survey done in Mbita constituency and nearby islands of western Kenya where prevalence was 61% (11). The differences could be explained by the fact that a larger section of the Mbita constituency borders Lake Victoria where water-borne activities are higher, increasing likelihood of infection. Similar to Mbita area, one of the sub-counties in our study (Nyatike constituency) is adjacent to Lake Victoria and also had a higher schistosomiasis prevalence of 43% compared to other sub-counties in the study.

Our study observed a lower prevalence of urogenital schistosomiasis in children when compared to intestinal schistosomiasis. The lower prevalence of urogenital schistosomiasis may be related to the distribution of the vector snails which mainly inhabit inland water bodies (ponds, water-points, streams, dams or rivers) (23). Higher prevalences of *S. mansoni* infection (64%)have been observed in north-western Tanzania (24). Apart from probable geographical and environmental differences in comparison to our study setting, this high prevalence could be attributable to the sample of older children (8–17 years) enrolled in this study and who generally have more exposure to water-borne activities. Similarly, our study found prevalences were consistently rising with age of children.

Nyatike constituency had the highest prevalence of schistosomiasis perhaps due to it closeness to the Lake Victoria. The differences in geographical attributes may also explain the difference in prevalences of schistosomiasis. Areas around the lake generally receive higher amounts of rainfall, providing pools of water which favour multiplication of the vectors. The fresh water lake and presence of many rivers provides a good environment for the proliferation of intermediate hosts, *Bulinus* Spp and *Biomphalaria* Spp. Poor sanitation may also contribute to the high schistosomiasis prevalence with sanitation facilities being few or lacking completely along the shores of the lake. Schistosome infections were also observed in schools in all the sampled constituencies including those which are farthest from the lake. This suggests that inland water bodies are potential transmission hotspots for the infections.

Intensity of *S. mansoni* infections seemed to reduce with age of infected school children, though not significantly. This could be attributable to the higher fecundity of the worms in younger children as their immunity is lower when compared to the older children (25). Compared to girls, boys were more likely to be infected with shistosomiasis and the most likely explanation for this is the higher chances of boys engaging in water contact activities such as swimming and fishing. Similar findings were reported in Northern Nigeria by Kabiru *et al*,who attributed the increased risk in boys to more frequent water contact in *cercariae* infested areas around rivers (26).

Older age was associated with higher odds of having shistosomiasis disease. Children in lower age groups were at a lower risk of infection likely due to limited exposure to the lake or other water bodies whilst older age groups have increased engagement in water contact activities. Children who went to schools in Nyatike constituency, which is near the shores of L. Victoria had the highest risk of shistosomiasis. Proximity to water sources is an important risk factor for infection with schistosome. This is because the schistosome parasite requires direct contact between the intermediate snail and the human host for transmission to occur. Consistent with our findings, a surveys conducted in Msambweni, Kenya showed that children whose schools were closer to open water bodies had increased risk of infection (27). No significant differences in schistosome infection intensities were observed between girls and boys. These findings are in concordant with those of a survey conducted in the wider western Kenya region by Sang and others (28).

The current study was conducted during the rainy season which could have resulted in underestimation of the disease burden. Studies have shown temporal variations in schistosomiasis prevalences with the peak prevalences occurring during the dry spell (29,30). Increased foecal and urine contamination of the water bodies and increased water contact frequency by the communities in the dry season could be one of the reasons for the phenomenon. Furthermore, the dry season provides a favorable environment for accumulation of snail populations. In the dry season, water levels, water temperature and water currents are more conducive as opposed to the rainy season whereby the heavy rains wash away most of the snails (30).

A strength of our study is that reporting in this study was in accordance with STROBE guidelines (15).We also followed the WHO guidelines for minimum sample size determination and sampling hence making our findings representative of schistosomiasis prevalence among children in this setting. The present study did not enroll children aged five and six years which limits the inference of study findings all to school-going age children (5-14 years). However, it is not expected that the inclusion of that age group would drastically skew findings towards higher prevalences and intensities of infection given observed lower prevalences among those who were younger. This study may have under estimated the actual prevalence of schistosomiasis in this area since only onespecimen was collected per participant. Optimisatio n of detection of schistosome eggs requires examination of specimens collected on two to three consecutive days which was not be achievable in our study due to resource constraints. Additionally, the Kato Katz technique used in processing stool samples has low sensitivity especially when the intensities of infections are not high as is the case in the study area.

The critical finding from this study was that the prevalence of schistosomiasis in Migori county exceeds 10% which is the threshold for mass drug administration. Treatment in Nyatike constituency should be conducted biannually as the area is classified as higher risk (schistosomias is prevalence greater than 50%). In other areas annual mass treatment would likely suffice.

In conclusion, the present survey showed that the study area is endemic for schistosomiasis. The disease represents a significant public health problem. It is thus imperative that the area be prioritised for interventions including conducting mass treatments and activities aimed at improving sanitation. There is also a need to complete the mapping of the disease in the study area by conducting a similar survey in constituencies which were not mapped. Lastly, there is a need to carry out a survey on vectors and map the transmission hotspots for schistosomiasis.

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