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Prevalence and intensity of *Schistosoma mansoni* and hookworm infections among pre-school and school-aged children in Ilemela District, north-western Tanzania

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Abstract
Introduction: World Health Organization have recently recommended the inclusion of pre-school children in the Mass Drug Administration (MDA) against schistosomiasis and soil-transmitted helminths in endemic areas. This study was conducted to determine the prevalence and intensity of *Schistosoma mansoni* and hookworm infections among pre- and school going children in Ilemela District, north-western Tanzania.
Methods: This cross-sectional study included pre- and school going children aged 4-14 years. A single stool sample was collected from each child and processed using Kato Katz thick smears and examined microscopically for presence of *S. mansoni* and hookworm eggs. A questionnaire was used to collect demographic information of the study participants.
Results: Overall, prevalence of *S. mansoni* was 80.0%; with pre-school children aged 4-6 years having the point prevalence of 60.6%. The overall prevalence of hookworm infection was 18.7%; with age group 4-6 years having the prevalence of 14.1%. The intensity of hookworm infection was light in all age groups. The intensity of infection of *S. mansoni* increased with age. Using lake water for domestic purposes (OR=3.09, 95% CI: 1.93-4.95, p<0.001), for bathing (OR=2.65, 95% CI: 1.66-4.23, p<0.0001), and for washing purposes (OR=3.08, 95% CI: 1.90-4.97, p<0.0001) remained independently associated with *S. mansoni* infection. Children who reported to swim in the lake and involved in paddy farming had 1.84 and 1.95 times odds of being infected than those who did not, respectively.
Conclusion: These findings indicate that *S. mansoni* and hookworm infections are common among pre-school children as well as in school going children. These findings call for the need to urgently include the pre-school age children in the MDA programme.

Keywords: Pre-school children, prevalence, *Schistosoma mansoni*, hookworm, Tanzania

Introduction

Schistosomiasis and soil transmitted helminths infections (STH) are among the neglected tropical diseases which are widely distributed in the worldwide. The former is estimated to infect over 230 million people and the later 3.5 billion people (Seto *et al.,* 2012; Pullan *et al.,* 2014). The sub-Saharan Africa region carries the highest burden of these infections, mainly because of poor sanitation and personal hygiene are low (Mascarini-Serra *et al.,* 2010). Overall, Tanzania is the second highest country in Africa for the number of people infected with schistosomiasis. It is estimated that 52% of the population in Tanzania is infected or at risk of being infected with schistosomiasis (Mazigo *et al.,* 2012). The prevalence and intensity of schistosomiasis in the country varies from one epidemiological setting to another.

Studies in Tanzania indicate that, the north-western regions which border the southern shores of the Lake Victoria carry the highest burden of schistosomiasis (Mazigo *et al.*, 2012; Mugono *et al.*, 2014; Bukindu *et al.*, 2016). Similarly, STH especially hookworms remain as an important public health problem in north-western Tanzania, with prevalence ranging from 2% - 40% among schoolchildren (Mazigo *et al*., 2010; Mugono *et al*., 2015).

The main strategy for controlling these infection is through Mass Drug Administration (MDA), which mainly focuses in distributing anthelminthics to school children (WHO, 2002).

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School MDA program is considered a cost effective means of reaching the majority of the school children in endemic areas who always carry the highest prevalence and intensity of infection (WHO., 2002). However, of recent, the approach has been criticised of leaving out pre- and non-school going children, especially children aged 2-6 years who have been reported to be infected with schistosomiasis and STH (Ruganuza *et al.*, 2015). In fact, pre-school accounts for 10-20% of the total population infected with STH worldwide (Albanico *et al*., 2008). Based on the evidence that pre-school age group is also infected, the World Health Organization has recommended the inclusion of the age group in the MDA programme (Ruganuza et al., 2015). However, there are limited data on the prevalence and intensity of schistosomiasis and STH among the pre-school children in most endemic areas of Tanzania. The present study was therefore conducted to determine the prevalence and intensity of *S. mansoni* and soil transmitted helminths infections among pre-school and school going children in Ilemela District of north-western Tanzania.

Materials and methods

Study area and study population

The study was conducted at Kayenze and Sangabuye villages in Ilemela district located between 32°E and 34°E and 2°S and 4°S on the southern shore of the Lake Victoria in north-western Tanzania. The region experiences temperature ranges from 25.7° C to 30.7°C and 1,000 mm of rainfall per year. Two schools of Sangabuye ward were purposely selected based on the fact that they are close to the shores of Lake Victoria and that had not been included in the schistosomiasis control programme. The majority of the inhabitants depend on the lake for domestic and economic activities including fishing, farming, washing, bathing, cooking, drinking and recreation. For preschool children some tend to play along the shores while others accompany their parents when cleaning their utensils and washing clothes, this increases the risk of being infected with *S. mansoni* or hookworm. According to the Tanzania national census, the population of Ilemela district in 2012 was 343,001 (NBS, 2013).

Study design and sampling

This was a cross sectional study conducted among pre-school attending village nursery schools and school aged children from local primary schools. Children were included in the study if (i) they were aged between 4-14 years; (ii) parents/guardians gave written informed consent; (iii) they gave an assent to participate; and (iv) they had no history of using anti-helminthic in the past 3-6 months. A total sample size of 350 children was required to obtain 95% confidence intervals of the prevalence of schistosomiasis and hookworm with a precision of 5%. To compensate for drop outs and incomplete/missing values as a result of non-respondents and uncompleted questionnaires, the final sample was increased by 30% to 454. Selection of the school children, and pre-school children, to participate in the study was achieved through the use of random sampling methods. From the attendance register, each child was given a unique identification number and a table of random number was used to selected study participants.

Data collection

A questionnaire based on the known risk factors for soil transmitted helminths and intestinal schistosomiasis was developed. Demographic information including sex, age, residence, school and village where the participants lived was recorded. Children were also asked if they participate in any of the economic activities such as in paddy farming or fishing. A single stool specimen was collected from each study participant for two consecutive days. From the stool samples collected on different days, two Kato Katz thick smears were prepared using a template of 41.7 mg at the school environment and examined for hookworm eggs within 30-60 minutes after slides preparation (Barda *et al*., 2015; Siqueira *et al.*, 2011). After 24 hours, the smears were independently examined by two laboratory technicians experienced with Kato Katz technique at

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the National Institute for Medical Research in Mwanza for presence of characteristics eggs of *S. mansoni*. For quality assurance, a random sample of 10% of the negative and positive of Kato Katz thick smears were re-examined by a third laboratory technician. Quality control for the hookworm eggs was carried out on 10% of the samples on the day of sample collection.

Data analysis

The quantitative data were double entered and managed in Census and survey processing system (CSPro) Version 4.1 and analysed using STATA 10 (StataCorp LP). The mean number of eggs for each infected child was computed by counting the total number of eggs multiplied by a factor of 24 to estimate infection intensities expressed as the number of eggs per gram of faeces (epg). The *S. mansoni* infection intensity was classified as light, moderate, or heavy where the egg count was in the range of 1-100 epg, 101-400 epg or >400 epg respectively (WHO, 2013). For STH the infection intensity was classified as light when the count was <1000 epg, moderate at 1000-3999 epg and heavy for >4000 epg (Knopp *et al.,* 2008; Sayasone *et al.*, 2015). Logistic regression was used to explore risk factors of *S. mansoni* and STH infections. Both crude odds ratios (OR) and 95% confidence intervals (CI), and then adjusting for age, sex and village were determined.

Ethical consideration

The study received ethical approval from the Medical Research Coordinating Committee of the National Institute for Medical Research Before carrying out the study, the study team visited the villages where leaders of the communities were met. The study objectives, procedures and benefits were explained to the care takers/parents of children before making request for their informed consent to have their children included in the study. Signed or thumbprint informed consent of parent/care takers were obtained. All study subjects were given standard treatment for hookworms and schistosomiasis according to the national guidelines.

Results

Socio-demographic characteristics

A total of 454 children were enrolled (males 215 and 239 females) into the study. The mean age was 9 years. Study participants were divided into three groups: pre-school children (4-6 years), early primary schoolchildren (7-10 years) and late primary schoolchildren (11-14 years) (Table 1).

Table 1: Age prevalence of hookworm and *Schistosoma mansoni* infection of children

Variable		Hookworm				*S. mansoni*			
		Kayenze n (%)	Sangabuye n (%)	All n (%)	p-value	Kayenze n (%)	Sangabuye n(%)	All n (%)	p-value
Age (years)	4-6	0 (0.0)	10(27.0)	10(14.1)	0.37	31 (91.2)	12 (32.4)	43(60.6)	<0.0001
	7-10	17(12.0)	38(24.1)	55 (18.3)		139 (97.9)	107 (67.7)	246 (82.0)	
	11-14	13(31.0)	7 (17.1)	20(24.1)		42 (100.0)	32 (78.1)	74(89.2)	
Sex	Male	13(12.6)	25 (22.3)	38(17.7)	0.69	100 (97.1)	76 (67.9)	176 (81.9)	0.32
	Female	17(14.8)	30 (24.2)	47(19.7)		112(97.4)	75 (60.5)	187(78.2)	
Overall		30(13.8%)	55(23.3%)	85(18.7%)		212(97.2)	151(64.0%)	363(80.0)	

Prevalence and intensity of S. mansoni and hookworm infection

S. mansoni and hookworm were the only parasites detected by the Kato Katz technique. The overall prevalence of hookworm infection was 18.7% (85/454). The age group specific prevalence was 14.1% in 4-6 years, 18.3% in 7-10 years and 24.1% in 11-14 years old children with no significance difference between age groups (p-value = 0.37) and sex (p-value = 0.69). The overall prevalence of *S. mansoni* was 80.0% (363/454). The age group specific prevalence of *S. mansoni* was 60.6% in the preschool children 4-6 years, 82.0% in those aged 7-10 years, and 89.2% in the age group of 11-

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14 years. The difference in prevalence of *S. mansoni* observed between age group was statistically significant (p-value < 0.0001) (Table 1).

Table 2: Intensity of *Schistosoma mansoni* infection by age and sex

	Variable	Kayenze				Sangabuye			
		Light n(%)	Moderate n(%)	Heavy n(%)	P-value	Light n(%)	Moderate n(%)	Heavy n(%)	P-Value
Age (years)	4-6	11 (32.4%)	10 (29.4%)	10 (29.4%)	<0.0001	8 (22.9%	4(11.4%)	0(0.0%)	<0.0001
	7-10	18 (12.7%)	51(36.0%)	70 (49.3%)		66(42.0%)	29(18.5%)	11 (7.0%)	
	11-14	0 (0%)	16 (38.1%)	10 (24.1%)		15 (37.5%)	7(17.5%)	8(22.5%)	
Sex	Male	13(12.6%)	40 (38.9%)	45 (43.7%)	0.625	108(97.1)	76(67.9)	92 (81.9)	0.356
	Female	15 (12.2%)	40 (32.2%)	66(53.0%)		120 (97.4)	75 (60.5)	97(78.2)	
Overall		28(12.8%)	80(36.7%)	111(51.0%)		228(96.6%)	151(64.0%)	189(89.0%)	

The intensity of hookworm infection both in Kayenze and Sangabuye was light in all age groups. There was a significant difference in intensity between the age groups (p-value <0.0001). Sixty-two percent of schoolchildren aged 11-14 years in Kayenze had heavy intensity of *S. mansoni* infection than those from Sangabuye village. There were no significant differences in the intensity of *S. mansoni* infection by sex between the two villages (Table 2).

Table 3: Association of *Schistosoma mansoni* infection with open water sources contact habits of children

Risk factor	Response	No. (%) Positive for *S. mansoni*	X^2 P value	Crude OR	95% CI
Use lake water for domestic purpose	Yes	257 (86.53)		3.09	1.93-4.95
	No	106 (67.52)	< 0.001*	1.00	
Use river water for domestic purpose	Yes	55 (74.32)		0.68	0.38-1.21
	No	305 (81.05)	0.186	1.00	
Use damp water for domestic purpose	Yes	42 (73.68)		0.66	0.35-1.26
	No	321 (80.86)	0.206	1.00	
Use lake/pond water for bathing	Yes	252 (85.71)		2.65	1.66-4.23
	No	111 (69.38)	0.0001*	1.00	
Use lake water for washing	Yes	227 (87.64)		3.08	1.90-4.97
	No	136 (69.64)	0.0001*	1.00	
Use river water for washing	Yes	48 (78.69)		0.91	0.471-1.77
	No	315 (80.15)	0.79	1.00	
Use pond water for washing	Yes	30 (75.0)		0.73	0.34-1.55
	No	333 (80.43)	0.412	1.00	
Bathing in the lake	Yes	159 (83.23)		1.44	0.89-2.32
	No	204(77.57)	0.136	1.00	
Fetching water in the lake	Yes	20 (80.0)		1.00	0.37-2.75
	No	79(79.95)	0.995	1.00	
Fording in transit	Yes	95 (78.51)		0.89	0.53-1.48
	No	268 (80.48)	0.643	1.00	
Swimming in the lake	Yes	144(85.71)		1.84	1.10-3.06
	No	219(76.57)	0.019	1.00	
Involved in paddy farming	Yes	83(87.37)		1.95	1.01-3.76
	No	280(77.99)	0.042	1.00	

***** The difference was statistically significant (P < 0.05)

Risk factors for* S. mansoni and *STH infection

Factors that were significantly associated with schistosomiasis infection in unadjusted analysis included, using lake water for domestic purposes (OR=3.09, 95% CI: 1.93-4.95, p<0.001), using lake

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water or pond for bathing (OR=2.65, 95% CI: 1.66-4.23, p<0.0001), and using lake water for washing purposes (OR=3.08, 95% CI: 1.90-4.97, p<0.0001. Children who reported to swim in the lake had 1.84 times higher odds of being infected than those who did not (OR=1.84, 95% CI: 1.10-3.06). Children who were frequently involved in paddy farming activities were 1.95 times more likely to have *S. mansoni* infection than those who did not (OR=1.95, 95% CI: 1.01- 3.76) (Table 3). After adjusting for age, sex and village, using lake water for domestic purpose and frequent use of lake water for washing were not associated with *S. mansoni* infection (OR 1.32, 95% CI: 0.77-2.28, P=0.32 and OR 1.48, 95% CI: 0.86-2.57, P=0.159, respectively) (Table 4).

Table 4: Odds ratios for factors associated with *S. mansoni* adjusted for age, sex and village

Risk factors	Response	Positive for *S. mansoni* n (%)	X^2 P value	Adjusted OR	95% CI
Use lake water for domestic purpose	Yes	257(86.53)		1.32	0.77-2.28
	No	106 (67.52)	0.315	1.00	
Use lake water/Pond for bathing	Yes	252 (85.71)		1.50	0.88-2.57
	No	111(69.38)	0.135	1.00	
Use lake water for washing purpose	Yes	227 (87.64)		1.48	0.86-2.57
	No	136 (69.74)	0.159	1.00	
Swimming in the lake	Yes	144 (85.71)		1.22	0.65-2.26
	No	219 (76.57)	0.658	1.00	
Paddy swimming	Yes	83 (87.37)		1.03	0.48-2.22
	No	280 (77.99)	0.942	1.00	

Table 5: Association of hookworm infection with soil contact habit of children aged 4-14 years

Risk factor	Response	No. (%) Positive for hookworm	X^2 P value	Crude OR	95% CI
Shoe wearing behaviour	Yes	382(18.8)		1	
	No	72 (18.1)	0.87	1.05	0.55-2.02
Washing hands after visiting latrines	Yes	56 (18.06)		1	
	No	29 (20.14)	0.598	1.07	0.83 -1.37
Wash hands before eating	Yes	83 (18.57)		1	
	No	2(28.57)	0.501	1.23	0.89-1.69
Soil eating habits	Yes	13 (14.13)		1	
	No	72 (19.89)	0.206	1.23	0.89-1.69
Washing fruits before eating	Yes	41(17.15)		1	
	No	25 (19.84)	0.592	1.20	0.69-2.08
	Sometimes	18(21.95)		1.36	0.73-2.53

There was no significant difference in hookworm infection among children who reported wearing shoes and those who did not or between those who reported washing their hands after visiting the toilet or washing hands before eating than those who did not (Table 5). On stratifying the children by school age and pre-school age there were no significant differences by shoe wearing or washing hands after visiting the toilets.

Discussion

The region of north-western Tanzania has been reported by several previous studies to be highly endemic to schistosomiasis and soil-transmitted helminths (Lwambo *et al.*, 1999; Kinung'hi *et al.*, 2014; Mazigo *et al.*, 2010; Mugono *et al.*, 2015). For the soil-transmitted helminths, hookworms

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appear to be a predominant species among children along the shore line of Lake Victoria (Lwambo *et al*., 1999: Mazigo *et al*., 2010). Similarly, the findings from this study demonstrate that *S. mansoni* and hookworm infections remain as significant public health problems among pre-school and school aged children in the study area.

Our findings on the high prevalence of *S. mansoni* infection among pre-school aged children in this region are corroborated with the finding of a recent study in the same age group by Ruganuza *et al.* (2015). Similar studies elsewhere in Sub-Saharan Africa have demonstrated that the pre-school aged group remains at high risk of developing significant hepatosplenic morbidities with increased age (Stothard & Gabrielli, 2007; Anon, 2010; Stothard *et al*., 2011; Hodges *et al.,* 2012; Coulibaly *et al.*, 2013). This is due to the fact that the age group is infected at young age and carry the infection for long periods before it is included in the MDA programmes. Unsparingly, this study complements the findings from other studies, indicating that the prevalence of S*. mansoni* and hookworm tends to increase across age groups. The explanation to this is the cumulative exposure to infection as water contact of the children increases with age. Like in this study, several other studies have already shown that the prevalence of *S. mansoni* infection is high in school aged than the pre-school children (Pereira *et al*., 2010; Mazigo *et al*., 2010; Mugono *et al.*, 2015).

The sex distribution of *S. mansoni* in this study did not show any significant variation. This indicates that children at this age group have the similar exposure to risk of being infected with *S. mansoni*. The findings are similar to those reported from northwest Ethiopia by Worku et al., 2014. However, other studies have reported higher prevalence of *S. mansoni* infection among boys than girls (Mazigo *et al*., 2010), most likely attributed to varied social-gender related reasons.

Three classes of intensity of *S. mansoni* infection in pre-school children (light, moderate and heavy) were observed in Kayenze; while for Sangabuye the most significant were the light and moderate intensities. The differences in intensities between the two villages are explained by the fact that Kayenze is closer to the lake (350 m) than Sangabuye (1,500 m). The close proximity of the lake to Kayenze defines the high frequency of visiting the lake for various domestic tasks. Our findings are consistent with the observations reported by Ruganuza *et al*. (2015) that going to the lake or living close to the lake are associated with risks of being infected with *S. mansoni*. The intensity of infection in pre-school children is lower than that of school age children because parental care is higher in this age group than in the school aged children, who are old enough to freely move about the lake shores alone.

In conclusion, the findings of this study indicate that the prevalence of intestinal schistosomiasis among pre-school and school-aged children in villages around Lake Victoria in Tanzania is high. This calls for the implementation of a coherent control strategy. There is a need for the National Schistosomiasis and Intestinal Worm Control Programme to include pre-school children in the interventions. A community sensitization programme to promote the provision of safe and adequate water supply, latrine construction and use to reduce open field defecation and health education is critical.

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Author contributions

SN conceived the study and developed the proposal; CK carried out the statistical analysis; and JT contributed to the analysis and interpretation of the data. All authors contributed to the design and data analysis, read and approved the final version of the manuscript.

Competing interests

None declared.

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