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BURDEN OF SOIL TRANSMITTED HELMINTHIASES IN PRIMARY SCHOOL CHILDREN IN MIGORI COUNTY, KENYA.

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ABSTRACT

Background: **Soil-transmitted helminthiases cause a substantial yet under-appreciated public health burden. School age children harbour the heaviest burden. Infected children experience growth stunting and diminished physical fitness as well as impaired memory and cognition. These adverse health consequences impair educational performance, and reduce school attendance. Determination of the burden is central to designing and implementing appropriate interventions.**
Objective: **To determine the burden of soil-transmitted helminthiases among primary school children in Migori County, Kenya.**
Design: **Descriptive cross-sectional study.**
Setting: **Primary schools in Migori County.**
***Subjects:*Children aged between seven and fourteen years.**
Results:* Overall, 17% of the children were diagnosed with soil-transmitted helminthiases. Ascaris lumbricoides infections were the most common (9%) followed by hookworm (7%) and** *Trichuris trichiura* **infections (3%). Hookworm prevalence was highest in the older children while** *A. lumbricoides* **infections were highest in younger children. Further, more boys than girls harboured hookworm infections (p<0.001). Hookworm-A. lumbricoides***, hookworm-***T. trichiura* **and** *A. lumbricoides-T. trichiura* **coinfections were observed in 2, 3 and 7% of the children respectively. Two children (1%) were infected with all three helminth infections. Majority of the infection were of light intensity. In 12 (39%) of the 31 sampled schools, the prevalence of helminthiasis was above 20%.**
Conclusion: **Soil transmitted helminthiases is still prevalent in the study area. Our findings also strongly suggest that deworming alone will not eliminate these infections. This may suggest a need to take a more comprehensive approach that incorporates, among other activities, improvement in sanitation and intensification of public health campaigns.**

INTRODUCTION

Soil transmitted helminths (STH) infections are among the most prevalent infections in the world and affect the poorest and most deprived communities (1).The STH species, namely, *Ascaris lumbricoides, Trichuris trichiura* and hookworm (*Necator americanus* and *Ancylostoma duodenale*), contribute the greatest burden among the neglected tropical diseases (NTDs) (2). Globally, it is estimated that 1.4 billion individuals are infected with *A. lumbricoides,* 1.3 billion by hookworms and 1.0 billion by *T. trichiura*(1,2). In Kenya, STH infections are widely distributed with more than 10 million people being infected and approximately 16.6 million people being at risk (3).

Global efforts to combat NTDs were renewed in 2012 following the launch of NTD Roadmap in London. The World Health Organization (WHO) and partners pledged to work towards control and elimination often NTDs by 2020. The STH infections are among the NTDs targeted for elimination by 2020(4).

Currently, administration of mass chemotherapy is the mainstay strategy in combating STH. Albendazole is the drug of choice for mass chemotherapy due its convenience (administered orally as a single dose), affordability and efficacy. Besides, it is safe for large-scale treatment (5,6). Mass chemotherapy principally target school age children because they typically harbour the heaviest worm and egg burdens at a time when they are undergoing physical and/or cognitive development(7). This is due, in part, to their hygiene and behavioural practices, determining higher exposures and rates of acquisition of infection (8). Schools are used as avenues for implementation of mass deworming programmes targeting school age children. These programmes provide a cost-effective way of reducing STH-related morbidity (7,9). In Kenya, deworming is carried out on an annual basis through the National School-based Deworming Programme (NSDP) which was initiated in 2009. The Programme aims to reduce the prevalence of STH in school age children to below 4% (10).

Soil transmitted helminthiases do not replicate inside the human host. This biological characteristic confers to them transmission dynamics that are rather distinct when compared to those of other pathogens such as bacteria or viruses. For instance, epidemiological assessmentof the burden due to STH involves a combination of two parameters – prevalence and intensity. This is due to the fact that morbidity is majorly a function of the quantity of worms infecting the human host, that is, the intensity of infection/worm burden) and not just the absence or presence of infection (11). WHO recommends the use of a combination of prevalence and intensity to classify communities into various STH transmission categories: categories I (high), II (medium) and III (low). The transmission categories are allocated to communities based on both the number of heavily infected people (whether they are more or less than 10%) and the prevalence of STH (greater or less than 50%). This information is utilised in algorithms to determine the sort of mass treatment to be carried out in a community(12,13).

In order to achieve the 2020 goal of interrupting the transmission of STH, there is need for up-to-date and localised information on the epidemiological status of communities with regard to STH infections. Provision of such information will provide a basis for judicious allocation of the limited resources available to combat STH infections. The current study sought to determine crucial epidemiologic information on the prevalence and intensity of STH infections among children attending primary schools in Migori County. The evidence generated in this study could be utilised in the design and implementation of future intervention strategies.Additionally, the findings also provide baseline information for future outcomes comparisons.

MATERIALS AND METHODS

Study design: A descriptive cross-sectional study, using previously collected programmatic data. In this study the STROBE guidelines were used to ensure the quality of reporting(14).

Study Setting: Kenya,located in eastern Africa, had an estimated population of over 46 million in 2015 (15). Children betweenfive to fourteen years accounted for 28% of the total country's population (16). The country is divided into 47 semi-autonomous counties.

Specific setting: Study data were collected in October 2014 in Migori County, Kenya. The county borders the world's second largest fresh water lake, Lake Victoria. Of the county's population of 917,170, 43% live below the poverty line (16). The count is further sub-divided into eight constituencies: Suna East, Suna West, Uriri, Awendo, Rongo, Nyatike, Kuria East and Kuria West. There were 788 primary schools in the county with a total enrolment of 307,931 children in 2014 (17). School age children in Migori County are treated annually for STH under the NSDP (10).

Study population: Thirty-one primary schools in the county were selected for the study. The study population was made of children aged seven to fourteen years enrolled in the selected public and private primary schools. Only children whose parents/caregivers consented to their participation were included in the study. The children also had to provide assent to participate

*Sample size :*The required minimum sample size was determined based on WHO guidelines, whereby in cases of varying climatic and geographical zones, a minimum sample of the 250 individuals, selected from each zone, is considered adequate for evaluation of prevalence and intensity of infections (13).

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: Outcome variables were the presence (or absence) of STH and intensity of infections. Independent variables included age, gender, school and locality. Study data were retrieved from the NTDU database together with the geo-coordinates of the schools.

Data collection procedures: Data on selected demographic characteristics like age and gender were recorded as samples were being collected. Stool samples were processed by Kato Katz technique (18). Duplicate slides of the resultant thick smears were observed under the microscope with the number of species-specific eggs observed being recorded. Ten per cent of the slides were re-examined by an independent microscopist for quality assurance purposes.
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. Data were analysed descriptively with chi-square test being used to establish associations between the intensity of infection with age group and gender. The Mann-Whitney U test was used to compare the median egg counts between males and females, and is reported with interquartile range (IQR). Binary logistic regression was used to estimate the adjusted odds ratios (AOR) and their respective 95% confidence intervals (CI) for factors associated with STH infection. Two-tailed p-values of <0.05 were considered statistically significant.

Ethics consideration: The data were de-identified and secured. The children provided assents while their parents gave informed consents. After completion of the survey, an annual mass treatment was conducted by the National School Based Deworming Programme and the NTD-Unit. Ethical reviews and approvals were provided by the ethics boards of Moi University/ MTRH (Eldoret, Kenya) and Médecins sans Frontières (Geneva, Switzerland). Permission for the study was granted by the NTD-Unit, Ministry of Health, Kenya.

RESULTS

The study recruited 1,735 school children aged between seven to fourteen years, of whom 873 (50%) were boys. Distribution of the participants by constituency of residence is as shown in Table 1.

Table 1
Demographic characteristics of school children enrolled in the soil transmitted helminthiases survey in Migori County, Kenya

Characteristic	Frequency (n=1735)	%
Age (years)		
7 - 8	60	4
9 - 10	437	25
11 - 12	775	45
13 - 14	463	27
Gender		
Male	873	50
Female	862	50
Constituency		
Migori	497	27
Rongo	114	7
Uriri	58	3
Kuria	574	33
		28
Nyatike	492	

Overall, 292 of the 1,735 children whose stool samples were examined were positive for at least one soil transmitted helminth infection (STH) thus a prevalence of 17% (95% confidence interval (CI): 15% - 19%). Hookworms, *A. lumbricoides* and *T. trichiura* infections were reported in 7%, 9% and 3% of the children respectively (Table 2).

Disaggregation of the prevalences of infections by the number of species of worms harboured showed that 254 (14.6%), 36 (2.1%) and 2 (0.1%) children harboured one, two and three species of intestinal worms respectively. Figure 1 presents the distribution of mono- and co-infections with STH amongst the infected children. Hookworm - *A. lumbricoides*, hookworm - *T. trichiura* and *A. lumbricoid*es - *T. trichiura* co-infections were observed in 2%, 3% and 7% of the children respectively. Besides, two children (1%) were found to be infected with all the three STH infections.

Figure 1: Venn diagram showing distribution of mono- and co-infections with STH among the infected school children in Migori County, Kenya (2014)

Analysis of overall STH infection showed that prevalence of infections increased with age. Hookworm prevalence was highest in the older children while *A. lumbricoides* infections were highest in younger children. Further, more boys than girls were diagnosed with hookworm infections (9% versus 5% respectively, $p<0.001$). Prevalence of *A. lumbricoides* and *T. trichiura* infections did not vary significantly by gender. The distribution of STH infections among children differed significantly by the constituency of residence as shown in Table 3.

Table 2
Prevalence of soil transmitted helminthiases among school children enrolled in the survey in Migori County, Kenya.

STH	No. (n=1735)	% (95% CI)
Any STH	292	16.8(15.1 - 18.6)
Hookworm	119	6.9 (5.7 - 8.0)
A. lumbricoides	155	8.9 (7.6 - 10.3)
T. trichiura	58	3.3 (2.5 - 4.2)

STH = Soil Transmitted Helminth; CI = Confidence Interval

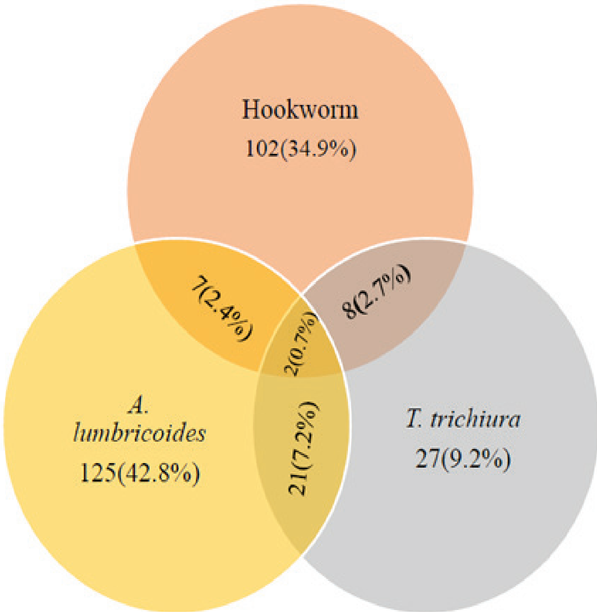
Table 3
Prevalence of soil transmitted helminths infection by locality, school, age and gender of the school children in Migori County, Kenya

			Type of infection (n, %)					
Characteristic	Total	STH* (n, %)	Hook-worm	P-value	*A. lumbri-coides*	P-value	*T. trichiura*	P-value
Age (years)								
7 - 8	60	7 (12)	1 (2)	0.006	7 (12)	0.6	1 (2	0.3
9 - 10	437	65 (15)	26 (6)		40 (9)		13 (3)	
11 - 12	775	136 (18)	45 (6)		73 (9)		33 (4)	
13 - 14	463	84 (18)	47 (10)		35 (8)		11 (2)	
Gender								
Male	873	178 (20)	79 (9)	<0.001	84 (10)	0.3	34 (4)	0.2
Female	862	114 (13)	40 (5)		71 (8)		24 (3)	
Constituency								
Migori	497	153 (31)	66 (13)	<0.001	72 (15)	<0.001	33 (7)	<0.001
Rongo	114	54 (47)	22 (19)		33 (29)		19 (17)	
Uriri	58	10 (17)	2 (3)		6 (10)		2 (3)	
Kuria	574	55 (10)	13 (2)		40 (7)		3 (1)	
Nyatike	492	20 (4)	16 (3)		4 (1)		1 (0)	

**Infection with at least one soil transmitted helminth (STH)*

Figure 1

Venn diagram showing distribution of mono- and co-infections with STH among the infected school children in Migori County, Kenya (2014)



In one of the 31 schools (3%) whose children, no case of STH was reported. The prevalence of infections in the schools where infections were observed ranged from 2% to 54%. In 12 schools (39%), the prevalence was above 20% while in the remaining schools (18, 58%), the prevalence of STH was less than 20%.

The geometric mean intensities of *A. lumbricoides*, hook worms and *T. trichura* were, respectively, 8778, 342 and 241 eggs per gram of stool. Generally, majority of the STH infections were of light intensity. Three children (3%) had heavy intensity hookworm infections (Table 4).

Table 4
Intensity of soil transmitted helminths infections among the infected school children in Migori County, Kenya

Helminth		Intensity† of infection		
	Mean (95% CI)	Light (n, %)	Moderate (n, %)	Heavy (n, %)
Hookworm	342 (193 - 491)	115(97)	1(1)	3(3)
A. lumbricoides	8778 (7334 - 10221)	78(50)	77(50)	-
T. trichiura	241 (68 - 415)	56(97)	2(3)	-

†Intensities (eggs per gram of stool): Hookworms - light (1-1999), moderate (2000-3999), heavy (≥4000): A. lumbricoides - light (1-4999), moderate (5000-49999), heavy (≥50000): T. trichiura - light (1-999), moderate (1000-9999), heavy (≥10000); CI = Confidence Interval

Table 5 outlines the distribution of infection intensities in children when examined by age, gender and locality. Light intensities of infections were more common in lower age groups except for *A. lumbricoides* infections where prevalence of light intensity infections was lowest in youngest children. Light intensity hookworm infections were more prevalent in girls than boys (respectively, 98% and 96%, p=0.01). Similar observation was made for light intensity *A. lumbricoides* infections. Light intensity *T. trichiura* were higher in males than females (100% against 92% respectively, p<0.001).

Gender was significantly associated with STH infections with boys being 70% more likely to be infected than girls (adjusted odd ratio (AOR): 1.6, 95% CI: 1.3 - 2.2), p<0.001). One year increase in age was associated with 20% reduction in likelihood of being diagnosed with STH (AOR: 0.8, 95% CI: 0.7 - 0.8), p<0.001). There were also significant variations of the infections across the sampled constituencies as shown in Table 6.

Table 5
Intensities of soil transmitted helminthiases by age, gender and locality of the school children in Migori County, Kenya

Characteristic	Intensity of infection† (n, %)						
	Hookworm			*A. lumbricoides*		*T. trichiura*	
	Light	Moderate	Heavy	Light	Moderate	Light	Moderate
Age (years)							
7 - 8	1 (100)	0	0	2 (29)	5 (71)	1 (100)	0
9 - 10	26 (100)	1 (0)	0	22 (55)	18 (45)	13 (100)	0
11 - 12	42 (93)	1 (2)	2 (4)	40 (55)	33 (45)	32 (97)	1 (3)
13 - 14	46 (98)	0	1 (2)	14 (40)	21 (60)	10 (91)	1 (9)
Gender							
Male	76 (96)	1 (1)	2 (3)	45 (54)	39 (46)	34 (100)	0
Female	39 (98)	0	1 (3)	33 (47)	38 (54)	22 (92)	2 (8)
Constituency							
Migori	63 (96)	1 (2)	2 (3)	40 (56)	32 (44)	32 (97)	1 (3)
Rongo	22 (100)	0	0	13 (39)	20 (61)	18 (95)	1 (5)
Uriri	2 (100)	0	1 (0)	4 (67)	2 (33)	2 (100)	0
Kuria	13 (100)	0	2 (0)	19 (48)	21 (53)	3 (100)	0
Nyatike	15 (94)	0	1 (6)	2 (50)	2 (50)	1 (100)	0

†*Intensity of infections (eggs/gram of faeces): Hookworm Light (1 - 1999) Moderate (2000 - 3999) Heavy (≥4000) A. lumbricoides: Light (1 - 4999) Moderate (5000 - 49999) Heavy (≥50000) T. trichiura: Light (1 - 999) Moderate (1000 - 9999 Heavy (≥10000)*

Table 6
Factors associated with soil transmitted helminthiases in school children of Migori County, Kenya

Characteristic	n (%)	OR* (95% CI†)	P-value	AOR§ (95% CI†)	P-value
Age (years)				0.8 (0.7 - 0.8)	<0.001
Sex					
Female	114 (13)	Ref			
Male	178 (20)	1.7 (1.3 - 2.2)	<0.001	1.6 (1.3 - 2.2)	<0.001
Constituency					
Nyatike	20 (4)	Ref			
Migori	153 (31)	10.5 (6.5 - 17.1)	<0.001	6.6 (4.4 - 9.7)	<0.001
Rongo	54 (47)	21.2 (11.9 - 37.9)	<0.001	13.9 (8.3 - 23.2)	<0.001
Uriri	10 (17)	4.9 (2.2 - 11.1)	<0.001	2.9 (1.4 - 6.3)	0.006
Kuria	55 (10)	2.5 (1.5 - 4.2)	<0.001	1.4 (0.9 - 2.2)	0.108

**OR = Odds ratio *AOR = Adjusted odds ratio †CI = Confidence intervals*

DISCUSSION

Our findings indicate that about one in six children in the study area suffers from STH infection. The overall prevalence of STH reported in our survey (17%) is lower than what was reported by a study conducted in Bumula, Western Kenya which found out that 28% of the children were infected with any STH species (19). The survey was conducted among school children of age range of 5 to 18 years.

There has been a declining trend in prevalence of STH over the years. Studies conducted in Western Kenya a decade ago revealed much higher prevalences of STH. For instance, a study done in 2003 by a team led by Handzel reported an overall STH prevalence of 63% (20). The decrease may be attributed, partly, to the introduction of the mass chemotherapy under the national school-based deworming.

A.lumbricoides was the most prevalent infection in the study area (9%) followed by hookworm (7%) and *T. trichiura* infections (3%). The survey conducted in Bumula, Western Kenya, reported higher prevalences with the most common species being hookworm (17%), followed by *A. lumbricoides* (15%) and *T. trichiura* occurred rarely (0.3%) (19). The socio-economic activities may explain the differences in these findings. Unlike the community in our study who rely mostly on fishing, the communities in Western Kenya are chiefly farmers which may expose them to hookworm infections.

The level of co-infections in our study were low with the prevalence's of infections with two and three species of intestinal worms being 2.1% and 0.1% respectively. The prevalence of single species infection was 14.6%. This is contrast with a study carried out in Ethiopia which reported much higher prevalence's with 54%, 23% and 5% of the children having a single, double and triple infections respectively (21). Both study sites were included in deworming programme for control of STH which indicates that re-infections are higher in the Ethiopian site. The higher re-infection rates could, most probably, be due to disparities in sanitation between the two sites with the Ethiopian site having poorer sanitation when compared to our study site. Another probable explanation would be the temporal variations in exposure, that is, the period between the time deworming was carried out and the time of conducting the survey could be greater for the Ethiopian cohort when compared to the Kenyan one.

The intensity of infection is a key epidemiological index utilised in profiling STH. The rate of transmission is directly related to the numbers of worms (intensity) harbored in the host (11). In the current study, the infections were majorly of light intensity which translates into reduced transmission of parasites in the community. These findings corroborate those of a study conducted in North-Western Tanzania in which the majority of the children had a light to moderate intensity of infections (22).

Our study demonstrated significant higher prevalence's of hookworm infections in boys than girls. This is in agreement with the findings of a study done in Côte d'Ivoire that involved school children (23). There were also significant variations in the distribution of STH infections by constituencies which possibly mirrors the differences on micro-climatic conditions as well as socio-economic and small-scale environmental factors.

To enhance validity of the findings, the current survey was conducted in accordance with the WHO guidelines with respect to sampling, processing and examination of specimens and quality control procedures (13,18). Besides, reporting of the findings adhered to the STROBE guidelines (14).

This study has a number of limitations. The diagnosis technique used, which involves checking for eggs by microscopy, may have missed some cases as a result of low intensity of infections in the study area. As a consequence, we may have underestimated the prevalence of STH in the study area. In addition, we collected very limited information on the children. The variables not included in the study such as socio-economic and behavioural factors have the potential of influencing our findings especially on risk factors for STH.

Effective targeting of mass drug administration for the treatment of soil-transmitted helminths (STH) require reliable, up-to-date data that indicate where prevalence exceeds the 20% intervention threshold recommended by the World Health Organization(9,13). In the present study 12 schools had a prevalence of above 20% thus qualifying for chemotherapy. However, there is a need to conduct routine surveillance in the other schools as quick resurgence of high burden of STH is highly probable.

Our findings on endemicity of STH among school children provides evidence of re-infection with STH following annual mass chemotherapy implemented in 2013 through NSDP (10). Additionally, it also shows that while mass chemotherapy approach has resulted in significant reduction in the burden of STH in the area, it cannot be solely relied on for sustainable reduction in STH. In future, there is a need to consider augmenting mass chemotherapy with other control activities such as improved water supplies and sanitation as well as intensive public health education aimed at bringing behavioural change.

CONCLUSIONS

Our findings demonstrate that STH is still endemic in the study area and poses a major health problem in school children. Most of the STH infections are of low intensity which may be attributed to re-infections occurring after the annual mass deworming exercise. This calls for incorporation of other public health interventions aimed at improving sanitation and increasing knowledge on STH in communities where they are endemic.

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