Original Article

Epidemiology of soil-transmitted helminths, Schistosoma mansoni, and haematocrit values among schoolchildren in Ethiopia

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Abstract
Introduction: This study aimed to determine the prevalence of intestinal helminths, risk factors and haematocrit values among primary schoolchildren.
Methodology: Across-sectional study was conducted in 12 primary schools in March 2011. Stool samples were randomly selected from 778 children and were microscopically examined using Kato-Katz and formal-ether concentration methods. Haematocrit values were measured using heparinized capillary tubes.
Results: The overall prevalence of intestinal helminths was 51.5% (rural = 68.3%, urban = 36.2%). Hookworm spp., *Schistosoma mansoni* and *Schistosoma stercoralis* were more prevalent in rural schools, whereas *Hymenolepis nana* was higher in urban schools (p = 0.0001). With regard to haematocrit, 34% of rural and 21.7% of urban schoolchildren had haematocrit values below the median (40.5%) (p=0.001). Hookworm spp. and *S. mansoni* infected children had lower haematocrit values than non-infected children (p = 0.001). Lack of footwear was positively associated with intestinal helminths infection in rural schools [OR = 2.5 (95% CI: 1.5-4.1)], and having dirty fingernails and untrimmed fingernails were positively associated with the prevalence of intestinal helminths in urban samples [OR = 1.58 (95% CI: 1.03-2.5)].
Conclusion: The prevalence of soil-transmitted helminths and *S. mansoni* differs by geographical area of the schools and social determinants. Primary school de-worming and health education on proper hygiene are recommended.

Key words: soil-transmitted helminthes; *S. mansoni*; haematocrit; primary schools; Ethiopia

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Introduction

Intestinal helminth infection and other parasitosis are relevant health problems in most developing countries. Approximately 2 billion people and 400 million school-age children are infected with intestinal helminths worldwide. Among intestinal helminths, soil-transmitted helminthes (STH) and schistosomes are the most prevalent parasites [1]. Among STH, *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm spp. and *Strongyloides stercoralis* have particular public health relevance because of significant child morbidities [2]. *A. lumbricoides* and *T. trichiura* are primarily spread through faecal transmission (usually ingestion of parasite eggs in faeces), whereas hookworm spp. and *S. stercoralis* is through skin penetration of infective larva.

The burden of soil-transmitted helminths and *S. mansoni* infections is being increasingly recognized as a significant public health problem, especially in poor populations in sub-Saharan Africa, as a result of inadequate sanitation, lack of clean drinking water and health care assistance, poverty and malnutrition [3,4]. STH and *S. mansoni* infections in children result in malnutrition, anaemia, and they have a negative impact on development and educational performance [5,6]. Control measures such as school-based de-worming programmes using antiparasitic therapy have been described as efficient, cost-effective and safe strategies for prevention and control of parasitic infections in schoolchildren [1].

In Ethiopia, the prevalence and distribution of STHs and *S. mansoni* differs by geographical location and climate. The prevalence of hookworm spp., *A. lumbricoides* and *T. trichiura* in children is estimated to be 16%, 37% and 30% respectively [7]. Previous Ethiopian research conducted in different parts of the country has shown that STH and *S. mansoni* prevalence is higher in the humid central highlands than in drier areas of the country [8-12]. In Ethiopian school-age children, *A. lumbricoides, T. trichiura*, hookworm spp*., S. stercoralis, Hymenolepis nana* and *S. mansoni* are the most common intestinal helminths [10,13-15]. However, the prevalence of STH and *S. mansoni* differ in each school due to different environmental conditions such as climate, humidity, ecology, and soil type [8-12]. Thus a survey of intestinal helminths and risk factors in the primary school population provides epidemiological information to design effective control programmes.

Bahir Dar special zone is situated in central highlands of Ethiopia. Its location and humid climate create an environment conducive for a high prevalence of STH and *S. mansoni.* A study conducted 16 years ago in an elementary school in Bahir Dartown reported high a prevalence of intestinal parasites [13]. No studies have been conducted since then; hence there is a lack of information on the prevalence, distribution and intensity of STH and *S. mansoni* infections, particularly regarding primary schoolchildren, who represent one of the most affected age groups in Bahir Dar special zone. The aim of this study was to determine the prevalence and intensity of intestinal helminths and their relationship with haematocrit values and anthropometric status as proxies for growth and health status in primary schoolchildren. The study also aimed to assess the differences between rural and urban schoolchildren according to local risk factors in Bahir Dar special zone.

Methodology

Study design and population

A cross-sectional study was conducted during the dry season of March 2011. The study was performed in Bahir Dar special zones (Northwest Ethiopia), which is situated 560 km from Addis Ababa. Bahir Dar is the capital of the Amhara National Regional State, which has 220,344 inhabitants [16]. It is situated 1,830m above sea level with an average annual temperature of 21.7°C and an average humidity rate of 23%. In this special zone, there are 50 primary schools; of these, 15 are situated in rural areas. The study population included children attending years 1-8 at 12 primary schools in Bahir Dartown special zone. Primary schoolchildren aged between 7 and 14 were selected.

Sample size and sampling

A random cluster sample of urban and rural schoolchildren was chosen separately. Since the prevalence rate (p) was unknown in the study areas, maximum prevalence (P = 50%) was assumed, with a marginal error of 5% and 95% confidence interval. For non-response rates, 5% of the sample size was included. Therefore, the total sample size was 791, with 394 children from rural areas and 397 children from urban areas. Five schools were rural and seven schools were urban, which were selected using a systematic selection method by calculating the sampling interval. The number of students to be surveyed was calculated by dividing the sample size by the number of schools to be included in the study. Classes were selected from each primary school with proportional allocation to class size, and students were selected randomly from a list provided by each school. The sampling procedure was performed with Epi Info software version 3.4.0.3 and Microsoft Excel 2003 (Microsoft Redmond, WA, USA, COUNTRY).

Data collection

A structured questionnaire translated into the local language was used to collect data such as students' age, sex, school year, height, weight, personal hygiene, and social determinants. The questionnaire was piloted in one school. Trained personnel administered the questionnaire. Each student from grade 4 and above completed the questionnaire, whereas students from grades 1 to 3 were given the questionnaire to be completed by their parents. During blood sample collection for haematocrit, the children's fingernails were also inspected to see whether they were trimmed and whether they were dirty.

Stool collection, examination and haematocrit determination

Following the questionnaire, each child was given a plastic container, an applicator stick, and instructions on how to collect and hand over the specimen. Stool samples were examined within 30 minutes of arrival using the Kato-Katz quantitative cellophane thick smear method (Mahidol University, Thailand) following the manufacturer's instructions [17]. All stool samples were re-examined microscopically using the formal ether concentration technique which is considered to be the most sensitive method for most intestinal helminths. The parasite infection intensity was determined in terms of eggs per gram (epg) of faeces. The epg value was obtained by multiplying the number of eggs counted on the slide by a fixed multiplication factor. The infection intensity of individual parasites was interpreted as light, moderate and heavy infection, based on the following World Health Organisation WHO) guidelines [18]: *S.*

mansoni [light (1-99 epg), moderate (100-399 epg), heavy (≥ 400); *A. lumbricoides* [light (1-4,999epg), moderate (5,000-49,999 epg), heavy (≥ 50,000 epg); *T. trichiura* [light (1-999epg), moderate (1000-9,999), heavy (≥ 10,000epg); hookworm spp. [light (1-1999epg), moderate (2,000-3,999epg), heavy (≥ 4,000 epg)].

To determine haematocrit levels, capillary blood was taken using heparinized capillary tubes from each child and centrifuged at 15,000 rpm for five minutes. The results were measured using a haematocrit reader.

Statistical analysis

First, we ran our samples through a descriptive analysis of parasite infections to assess parasite prevalence. The intensity of infection was determined as explained above. To identify the risk factors for parasite infections, we performed a bivariate analysis. We estimated an odds ratio for categorical variables. In the analysis, p-values less than 0.05 were considered statistically significant. Stepwise multivariable analysis was performed for the total study population as well as for each school setting. The chosen cut-off to keep the significant variables in the model was 0.10. Mann-Whitney U rank test was used to calculate the mean haematocrit difference between helminthes-free and parasite-infected children. Data was entered and analyzed using SPSS version 16 and STATA 10 software (SPSS, IBM, Chicago, USA).

Ethical considerations

The study was approved by the Research Ethics Committee of Bahir Dar University. Written permission was requested from the Education Office in Bahir Dar special zone and from each of the participating schools. Participants found positive for intestinal parasites were treated with anti-helminths drugs.

Results

Descriptive analysis and helminthes prevalence

This study included 381 girls (49%) and 397 boys (51%). The response rate was 98.4%. Among these, 372 children (47.8%) were from rural primary schools and 406 children (52.2%) were from urban primary schools. The mean age of the children was 11.35 years. Sex and age distribution were similar in both settings. Overall, the median body mass index (BMI) was 16.9 (with a range of 10. 05 to 36. 93) and the median haematocrit was 40.5% (with a range of 21-56%).

Overall, 401 schoolchildren (51.5%) were infected with intestinal helminths. The overall prevalence of intestinal helminths in rural schoolchildren was 68.3% (254/372) while in urban schoolchildren it was 36.2% (n = 147). The prevalence of STHs and *S. mansoni* was 361 (46.4%) and 57 (7.3%), respectively.

Among eight species of intestinal helminths isolated, hookworm was the most common, followed by *A. lumbricoides, H. nana* and *S. mansoni.* Significant association between parasitosis and school setting were found for hookworm spp., *S. stercolaris*, and *H. nana* (Table 1).

Double and triple intestinal helminths infection was found in 69 (8.86%) and 9 (1.2%), samples respectively. The most frequently combined helminths were hookworm spp. with *A. lumbricoides* (24 cases, 30.7%) and hookworm spp. with *S. mansoni* (17 cases, 21.8%). Moderate infection intensity was observed for hookworm, *A. lumbricoides*, *S. mansoni* and *T. trichiura*; however, four (9.8%) participants had *S. mansoni* heavy infection intensity (Table 2).

A statistically significant difference was not observed between girls and boys for *S. mansoni* infection and STHs. The prevalence of hookworm spp. and *S. stercoralis* infections increased with age from 11 to 14 years old (p = 0.01) (Table 3). With regard to helminths prevalence by area, hookworm spp., *S. mansoni* and *S. stercoralis* infections were higher in rural than urban schoolchildren. The prevalence of hookworm spp. varied among rural schools ranging from 27.6% to 54.8%. *S. mansoni* infection was found in all rural schoolchildren and 57% (4/7) of urban schoolchildren. The prevalence of *S. mansoni* infection was higher (23.3%) in two rural schools than in the other three rural schools. However, the prevalence of *H. nana* infection was higher in urban schoolchildren (Table 1).

Among the 778 surveyed schoolchildren, 110 (14.1%) were categorized as thin/underweight (less than -2SD) and 76 (9.7%) were dangerously underweight (< -3SD) when assessed by Z-score of height-forage standards for the 5 to 19 years age group [19]. There was no association between intestinal helminthic infections and stunting (*i.e.*, underweight and dangerously underweight) as defined by height-for-age Z-score. There was a higher prevalence of underweight and dangerously underweight boys than girls, but this difference was not statistically significant. An important association was not found between infection intensity and anthropometric indices.

Table 1. Prevalence of intestinal helminths among rural and urban school children in Bahir Dartown, 2011

Intestinal helminths	School setting						Odds ratio rural /urban (95% CI)	P-value
	Total		Rural (n = 372)		Urban (n = 406)			
	n	%	n	%	n	%		
Soil-transmitted helminths								
Hookworm spp.	224	28.8	176	47.3	48	11.8	6.84 (4.70-10)	0.000
A. lumbricoides	99	12.7	46	12.4	53	13	0.89 (0,56-1.40)	0.773
S. stercoralis	27	3.47	19	5.1	8	2.0	2.68 (1,10-7.15)	0.017
E. vermicularis	3	0.4	0	0.00	4	0.7	N/A.	N/A
T. trichiura	7	1.0	4	1.07	3	0.7	1.46 (0.25-10.03)	N/A
Schistosomiasis								
S. mansoni	57	7.3	49	13.7	8	2.0	7.55 (3.47-18.68)	0.000
Cestodes								
H. nana	58	7.4	15	4.0	43	10.6	2.8 (1.48-5.5)	0.001
Taenia spp	10	1.3	8	2.01	2	0.50	4.44 (0.88-43.10)	0.040
Overall prevalence	401	51.5	254	68.3	147	36.2	3.87 (2.87-5.27)	0.000

N/A: not applicable (at least one box with value 0)

Table 2. Infection intensity profile for *S. mansoni* and STH among schoolchildren in Bahir Dartown, 2011

Intestinal helminths	Infection intensity profile n (%)			Mean (epg)
	Light	Moderate	Heavy	
Hookworm spp. (n = 224)	216 (96.4)	8 (3.6)	-	206.7
A. lumbricoides (n = 99)	96 (96.9)	3 (3.1)	-	491
S. mansoni (n = 57)	38 (66.6)	15 (26.3)	4 (9.8)	66.8
T. trichuria (n = 7)	6 (85.7)	1 (14.3)	-	85.7

Attempts were made to determine the haematocrit values of schoolchildren. In reference to the median haematocrit value, a statistically significant difference was found between rural and urban schoolchildren. From all examined children, 34% of rural and 21.7% of urban schoolchildren had haematocrit values below the median (40.5%) ($p = 0.001$). The mean haematocrit values of hookworm spp. and S. mansoni in infected children and helminth-free children were 39.8%, 38.1% and 41.2%, respectively. Therefore, hookworm spp. and S. mansoni-infected children had significantly lower mean haematocrit values than helminth-free children as determined by the Mann-Whitney U test ($p < 0.001$). Among hookworm- and S. mansoni-infected children, 61 (27.2%) hookworm- and 19 (33.3%) S. mansoni-infected children were anaemic, with a haematocrit value below 37%. However, no statistically significant differences were observed in children infected with *A. lumbricoides*, *S. stercoralis* and *H. nana* (Table 4).

Intestinal parasitoses and risk factors

In this local study, risk factors for intestinal helminths infection were assessed. In univariate analysis, significant positive associations were found in the presence of intestinal helminths infection in children who defecated in open fields and poor hygiene practices, such as having untrimmed fingernails, dirt under the nails, and lack of footwear. Children from rural schools were 3.87 times more likely to be infected with intestinal helminths than urban schoolchildren (Table 3). Moreover, the education level of a child's mother had a positive association with intestinal helminths infection; *i.e.*, prevalence of intestinal helminths was lower in children whose mothers had high levels of education.

Table 3. Differences in intestinal helminths prevalence regarding risk factors and social determinants in schoolchildren in Bahir Dartown, 2011

Variables		**Intestinal helminths infection**		**OR (95% CI)**
		Yes	**No**	
School setting	Urban	147	259	3.87* (2.84-5.27)
	Rural	254	118	
Sex	Boys	195	202	0.86 (0.64-1,14)
	Girls	202	179	
Age group	7-10 years	132	161	1.47 * (1.09-1.99)
	11-14 years	265	220	
Religion	Christian	364	347	0.84 (0,49-1,45)
	Others	30	34	
Mother´s level of education	No formal education	256	235	0.89 (0,66-1,20)
	Primary or above	141	146	
Shoe-wearer	Yes	306	354	0.26*(0,16-0,41)
	No	91	27	
Latrine use	Open field	125	116	3.4* (2.4-4.8)
	Toilet use	201	181	
Fingernails trimmed	Yes	133	168	0,64* (0,47-0,86)
	No	264	213	
Dirt matter under the nails	Yes	264	211	1.61* (1,19-2,18)
	No	132	170	

* Significant association

Table 4. Association between STH, *S. mansoni* and hematocrit values of children, Bahir Dartown, 2011

Variables		**No. of children whose hematocrit was below the median (< 40.5%)**	**OR (95% CI)**	**p- value**
School setting	Rural	126 (33.9)	1.56* (1.15-2.1)	0.001
	Urban	88 (21.7)		
Sex	boys (n = 397)	116 (29.2)	1.1 (0.8-1.5)	0.5
	girls (n = 381)	98 (25.7)		
Hookworm spp.	Yes (n = 224)	129 (57.6)	3.75* (2.7-5.2)	0.001
	No (n = 554)	85 (15.3)		
A. lumbricoides	Yes (n = 99)	30 (30)	1.1 (0.7-1.7)	0.37
	No (n = 679)	184 (27.1)		
S. mansoni	Yes(n = 57)	22 (38.6)	1.45* (0.84-2.5)	0.007
	No (n = 721)	192 (26.6		
S. stercoralis	Yes (n = 27)	7 (25.9)	1.0 (0.4-2.4)	0.63
	No (n = 751)	207 (27.5)		
H. nana	Yes (n = 58)	18 (31.0)	1.14 (0.6-1.9)	0.63
	No (n = 720)	196 (27.2)		

* Significant association
P value based on χ^2-test

Children aged 11 to 14 years were more likely to harbour intestinal helminths.

Multivariate analysis was calculated for variables that showed significant association in bivariate analysis. Therefore, school setting and shoe-wearing habits were the most determinant risk factors for overall prevalence of intestinal helminths infection with the odds ratio of 3.1 (95% CI: 2.3-4.3) and OR 2.6 (95% CI: 1.6-4.2), respectively (Table 5). At the time of the survey, all primary schoolchildren reported that they had never received de-worming chemotherapy or health education on hygiene and intestinal parasitosis.

Discussion

In this study, the prevalence and distribution of intestinal helminths among primary schools varied according to where the children lived. Therefore, knowledge of the prevailing distribution and intensity of intestinal helminthic infection in each local area was essential for planning, implementing, and evaluating intervention programmes.

Distinct differences were observed in the patterns of intestinal helminths infection in urban and rural schoolchildren. The overall prevalence was significantly higher in rural schoolchildren than in urban schoolchildren. Similarly, a higher prevalence of intestinal parasitoses in rural children was reported in Malawi [4]. There were also huge differences in the prevalence of intestinal helminths infection among rural schools, which ranged from 48.3% to 80%. Subtle differences were also observed among urban schools, which ranged from 25.4% prevalence in privately owned schools to 50% in public schools. These differences might be attributed to local risk factors. For instance, from multivariate analysis, the most important independent risk factors for intestinal helminths infection in rural children was their lack of footwear [adjusted OR = 2.5 (95% CI: 1.5-4.1), p = 0.001]. This positive association can be explained by the fact that the mode of transmission of hookworm spp. and *S. stercoralis* is through barefoot penetration by infective filariform larva, which might be the reason that these parasites were more prevalent in rural schoolchildren than in urban schoolchildren.

An interesting observation in the present study was the higher prevalence of *H. nana* in urban schoolchildren, which correlated with a previous study conducted on primary schoolchildren in urban and rural communities in Zimbabwe [20]. This observation might be associated with the presence of infected siblings in urban areas, as *H. nana* can be acquired through oro-faecal contaminated fingers. In this study, significant univariate association was identified with

Table 5. Difference in parasitosis prevalence regarding risk factors and social determinants stratified by school setting in school children in Bahir Dartown, 2011

Variables		**Rural**			**Urban**		
		Intestinal helminths		**OR (C.I. 95%)**	**Intestinal helminths**		**OR (C.I. 95%)**
		Yes	**No**		**Yes**	**No**	
Sex	Girls (n = 381)	120	174	0.92 (0.58-1.46)	82	125	0.69 (0.45-1.06)
	Boys (n = 397)	133	198		62	137	
Age group	7-10 years	83	52	1.59 (0.99-2.55)*	49	109	1.38 (0.89-2.16)
	11-14 years	170	67		95	153	
Religion	Christian	243	118	3.88 (0.51-173.79)	121	229	1.26 (0.67-2,34)
	Other	8	1		22	33	
Mother´s level of education	No formal education	161	71	0.85 (0.53-1.36)	95	164	0,86 (0.65-1,35)
	Primary or above	92	48		49	98	
Shoe-wearer	Yes	171	100	2.5 (1.5-4.1)*	135	254	0.47* (0.16-1.42)
	No	82	19		9	8	
Latrine use	Open field	81	42	1	44	74	1
	Toilet use	123	52	1.06 (0.91-1.25)	78	129	1.01 (0.75-1.35)
Fingers nails trimmed	Yes	75	30	1.25 (0.74-2.13)	58	138	0.61* (0.39-0.93)
	No	178	89		86	124	
Dirt matter under the nails	Yes	180	87	0.91 (0.54-1.51)	84	124	1.58* (1.03-2.54)*
	No	73	32		59	138	

*Significant association

the presence of dirt under the fingernails [OR = 1.58 (95% CI: 1.03-2.54), p = 0.001] for intestinal helminths infection in urban schools (Table 5).

High prevalence and distribution of *S. mansoni* and STH provide important epidemiological information that is useful in the planning of control measures. The WHO recommendations to control STH and *S. mansoni* are different based on levels of prevalence and infection intensity [8,9]. Thus, based on WHO recommendations, 60% (3/5) of the surveyed rural schools, which had high prevalence (*i.e.*, prevalence exceeds 70%), would require mass treatment for STH two to three times a year [8]. However, 40% (2/5) of the rural schools, which had *S. mansoni* prevalence ≥ 20% but < 50% and therefore were classified as moderate risk, would require mass treatment once every two years for intestinal schistosomiasis [9]. In contrast, all surveyed urban schools and two of the rural schools with STH prevalence of < 50% (classified as low prevalence and low intensity*)* would require mass treatment for STH once each year [9].

Attempts were made to correlate intestinal helminthic infection and haematocrit values. Haematocrit reference values vary with age, sex and altitude; hence interpreting this factor as anaemic or non-anaemic could be difficult for children. Therefore, median value was taken as a reference for interpreting haematocrit values. Statistical significant difference was observed between rural and urban schoolchildren with haematocrit values, as more rural schoolchildren had haematocrit values below the median value (40.5%) than urban schoolchildren (p = 0.001). In this study, hookworm spp.- and *S. mansoni*-infected children had lower haematocrit values than non-infected children. In agreement with this study, Dori *et al.* (2011) reported that an association between hookworm spp. infection and anaemia was found [21]. However, Legesse *et al.* (2004) reported that there was no association between hookworm spp. infection and low haematocrit values among schoolchildren [10]. This discrepancy could be explained by the differences in the intensity of hookworm spp. infection, the nutritional status of the children [22] and the differences in hookworm spp. species [23].

Height-for-age based anthropometric measurements in children are important tools for gauging nutritional status. In this study, the overall prevalence of intestinal helminth infection was not statistically different among underweight children, dangerously underweight children, and normal weight children (p > 0.05). This result is in agreement with those of previous studies conducted in Ethiopia [24,25]. However, among the detected intestinal helminths, *H. nana* and *A. lumbricoides* showed higher prevalence in stunted (underweight and dangerously underweight) than normal weight children. Prevalence of *H. nana* infection in those of stunted growth was 34.5% and 5.3% in normal weight children, respectively (p = 0.001). This result is in agreement with those of other studies conducted with schoolchildren in Ethiopia [14], Egypt [25], and Mexico [26]. The prevalence of *A. lumbricoides* in stunted growth (underweight and dangerously underweight) children was 22.2% and 11.3% in normal weight children (p = 0.001). In this study, the negative impact of intestinal helminths infection on children's educational performances was not assessed. The influence of seasonal variation on parasite prevalence could not be determined.

Conclusion

In conclusion, the prevalence and distribution of STH and *S. mansoni* varies by school location. Moreover, there was no de-worming programme or health education targeted at the prevention and control of intestinal helminthic infections in primary schools. This study highlights the need for periodical school de-worming interventions to control child morbidity associated with STH and *S. mansoni* infections. Appropriate health education along and de-worming interventions are recommended to reduce worm burden among schoolchildren in Ethiopia.

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