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ORIGINAL RESEARCH

Prevalence, Infection Intensity and Associated Factors of Soil-Transmitted Helminthiasis Among School-Aged Children from Selected Districts in Northwest Ethiopia

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Background: Globally, soil-transmitted helminths affect beyond a billion people and cause 1.9 million disability-adjusted life years worldwide. It affects children disproportionately due to their unaware activities like walking barefoot, playing with dirty objects that might be contaminated with feces. The control of soil-transmitted helminths principally relies on periodic deworming using either a single dose of albendazole/mebendazole. To assure the effectiveness of this measure, performing continuous parasitological survey is necessary. Herein, the prevalence, intensity and associated factors of soil-transmitted helminth infections were assessed among school-aged children in northwest Ethiopia.

Methods: A cross-sectional study design was conducted among school-aged children (6–14 years old) from January 21st to February 21st/2019. Multistage sampling technique was employed. A Kato-Katz concentration technique was utilized to detect STHs in stool samples. Moreover, risk factors for STH infections were assessed using well-structured questionnaire. Bivariate and multivariate analyses were used to assess the association between explanatory and the outcome variables. The magnitude of the association was measured using the adjusted odds ratio (AOR) and 95% confidence interval (CI). A *P-value* <0.05 was considered statistically significant.

Results: The overall STHs prevalence in this study was 32.3% (95% CI: 29–35.6%) with *Ascaris lumbricoides* being the predominant species (24.3%) followed by hookworm (8.9%) and *Trichuris trichiura* (1%). Most (80.3%) of the infected school-aged children had light-intensity infections. Age of 11 years and above (AOR, 12.9, 95% CI, 1.6–103.6, *P*=0.004), being residing in Chuahit district (AOR, 3.9, 95% CI, 2.3–6.5, *P*<0.001), and untreated water supply (AOR, 1.7, 95% CI, 1.1–2.7, *P*=0.018) were identified as predictors for the overall STH prevalence.

Conclusion: Our findings revealed STH infections are considerable health problems in the study areas. Thus, public health interventions such as provision of safe water supply, health education, and de-worming programs should be regularly implemented in the study areas.

Keywords: STH, helminths, prevalence, northwest Ethiopia

Background

Globally, the burden of Soil-Transmitted Helminths (STHs) ie *Ascaris lumbricoides, Trichuris trichiura*, and hookworm (*Ancylostoma duodenale* and *Necator americanus*) infections remained high, and continues to have a devastating impact on people's health especially among individuals in low- and middle-income countries.[1] In 2017, the global burden of STHs was estimated at 1.9 million disable-adjusted life

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years (DALYs).[2] Moreover, currently more than one billion people are affected by STHs worldwide.[1] Tropical and subtropical regions are the most hotspot areas for STH infections, the greatest numbers of the case occur in sub-Saharan Africa (SSA), the Americas, China, and East Asia.[3]

In SSA regions over one quarter of the population is affected with one or more STH infections, especially children, disproportionately affected.[4] The disproportionate effect of STHs in children might be due to unaware activities like walking barefoot, playing with dirty objects that might be contaminated with feces, and fetching of unclean water for drinking and to not fully developed immune systems.[5] Factors such as low household income, poor personal and environmental sanitation, over-crowding, limited access to clean water, tropical climate and low altitude are significantly associated with the occurrence of high intestinal parasitic infections especially in tropical and sub-tropical areas.[6–8]

The burden of the disease is mainly attributed to their chronic and insidious impact on the health and quality of life of infected individuals rather than to the mortality they cause.[3,9] Such adverse effects of STH infections among children are so diverse and alarming. They have detrimental effects on their survival, as well as mental and physical development. Moreover, they are associated with poor school performance and absenteeism in children.[10,11]

The current global strategy for the control of STH infections is implemented through regular mass drug administration using regular anti-helminthic treatment, health education, sanitation and personal hygiene, and other means of prevention with vaccines and remote sensing.[3,12,13] According to the World Health Organization (WHO) reports, an estimate of around 267.5 million preschool-aged children and 568.8 million school-aged children requires treatment across 103 countries endemic to STH.[14] The major objective of control approach using mass drug administration as a preventive chemotherapy is to eliminate morbidity in the target population by reducing the prevalence of moderate- and heavy-intensity infections to <2%.[15,16]

Therefore, regular parasitological surveys are essential to produce up to date data on the prevalence and infection intensity to evaluate the implementing prevention and control measures. Moreover, continuous evaluation and monitoring of the prevalence status of STH are crucial to map additional or alternative control strategies according to the finding. Despite the existence of many recent epidemiological studies documented with a high burden of intestinal parasites in Ethiopia,[17–20] there has been no recently published report on the magnitude of STHs among elementary school-aged children in the current study districts, Northwest Ethiopia. Therefore, in this study, we were initiated to determine the current prevalence, infection intensity of STHs and associated factors of infection among school-aged children of four selected districts in Northwest Ethiopia.

Materials and Methods

Study Area

The study was conducted in four different districts of primary schools in the northwest part of Ethiopia. Study participants were from Sanja (13°20′N/36°45′E), Maksegnit (12°40′N/37°20′E, one of the *kebeles* in Gondar Zuria), Debark (13°08′N/37°54′E), and Chuahit (one of the *kebeles* from Dembia) (12°40′N/37°10′E) districts. According to previously published reports and current unpublished data available in the health centers indicating all of the study areas included in this study are among the predominant sites where intestinal parasitosis are predominant in northwest Ethiopia.

Study Design and Period

A school-based cross-sectional study was conducted to determine the prevalence, infection intensity, and associated factors of STHs among school-aged children whose age ranged from 6 to 14 years old from January 21st to February 21st/2019.

Sample Size and Sampling Technique

The required sample size was determined using a single population proportion formula[21] and considering 37.1%[22] prevalence rate in the population, 95% confidence level, a 5% expected margin of error and a 10% non-response rate. Accordingly, the calculated sample size was 395. The design effect of two (to minimize error arising from sampling procedure) was used to allow for multistage sampling techniques; and hence, the final sample size was calculated to be 790. The source of population for the study was elementary school-aged children.

Prior to the study initiation, based on the accessibility of transportation, only four districts were selected purposefully from Northwest Ethiopia. Then, the sample size was proportionally allocated to each district, school and class section based on the total number of students who were attending primary school during the study period. Students' enrollment lists were taken as the sampling frame. Finally, study participants were selected using systematic random sampling technique (see Figure 1).

Inclusion and Exclusion Criteria

Participants who had a written informed consent and all randomly selected school-aged children in the selected schools who were agreed to provide all required socio-demographic data and stool sample were included.

Exclusion Criteria

Participants who were on anti-helminthic drug within the past two months prior to data collection and participant who were unable to provide sufficient stool sample were excluded.

Data Collection and Laboratory Procedures

Socio-Demographic Data and Risk Assessment of the Study Participants

Prior to the laboratory investigation, a pre-tested and well-structured questionnaire was prepared in English and translated to Amharic, the local language, was used to collect socio-demographic data and associated factors of the study participants. Trained data collectors were recruited for data collection and supervision was made by the investigators. At each of the data collection spot, sufficient explanation about the aim of the study was given to the students, school teachers and parents. A unique identification number was given to each study participant.

Stool Sample Collection and Laboratory Procedures

After the collection of essential participant related data, each participant received a sterile stool container labeled with his/her unique identification number and was asked to provide approximately 3g of fresh stool samples. The children were instructed on how to provide stool specimen and remained to avoiding contamination with urine. The specimens were collected at each school and immediately (within four hours of collection) transported to University of Gondar, department of medical parasitology laboratory. Each stool sample was examined by direct wet mount microscopy and two slides Kato-Katz technique. Hookworm ova detection was performed by examination of the Kato-Katz slides within one hour of its preparation. For identification of the other two helminths ova, the prepared Kato-Katz slides were left for 24 h for better clearing and easy visualization of eggs. Infection intensity of the STHs was estimated by multiplying the total number of eggs counted by 24, which gives as the eggs per gram (epg) of stool. Besides, the species-specific classes of infection intensity were classified as light, moderate and heavy as per the threshold set by

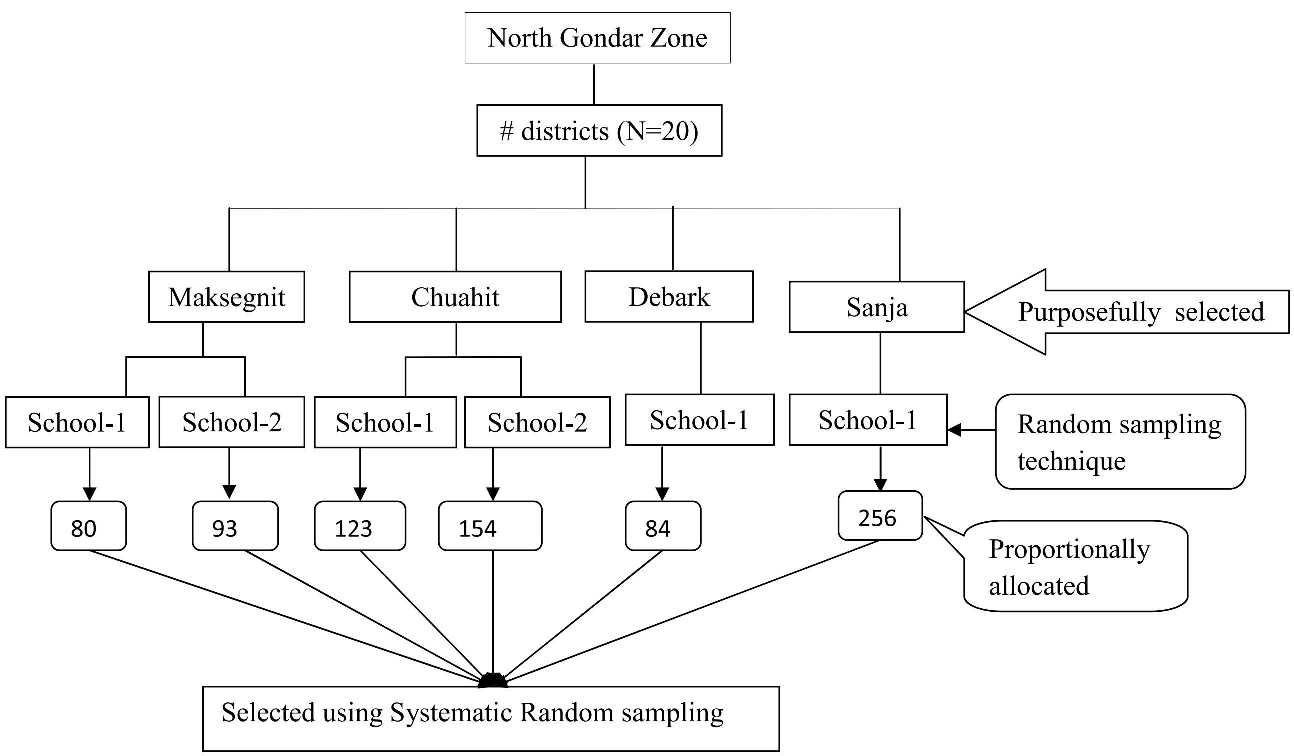

Figure 1 Diagramatical presentation of sampling techniques.

WHO and classified as A. *lumbricoides*: light infection (1–4999epg), moderate (5000–49999epg) and heavy (greater than 50,000epg). Intensity of *T. trichiura*: light infection (1–999epg), moderate (1000–9999epg) and heavy (greater than 10,000epg). Classification of Hookworm: light infection (1–1999epg), moderate (2000–3999 epg) and heavy (greater than 4000epg).[23]

Data Management and Analysis

Data was entered to Epi-data software to assure the data completeness and clearance, and transferred to SPSS version 20 software package for further statistical analysis. Descriptive statistics (mean, standard deviation, and percentages) were used to summarize the demographic profile of the study participants. Levene's and Kolmogorov–Simonov's statistical tests were carried out to check the homogeneity and the normality of data, respectively. Bivariate and multivariate analyses were used to assess the association between explanatory and the outcome variables. Variables with *p-value*<0.25 in the bivariate analysis were subjected to further multivariate logistic regression analysis model to identify predictor variables and to control cofounders. Then, the study findings were explained using tables. The magnitude of the association was measured using adjusted odds ratio (AOR) and 95% confidence interval (CI). A *P-value*<0.05 was considered statistically significant.

Result

Socio-Demographic Characteristics of Study Participants

A total of 786 school-aged children participated in this study with a response rate of 99.5%. Out of these, 452 (57.5%) were female. The mean age of the participants was 10.64 ±1.8 years and the majority (68.3%) was within the age group of 8–11 years. The study participants were from four different districts. 21.9%, 10.6%, 32.4%, and 35.1% were from Maksegnit, Debark, Sanja, and Chuahit, respectively. Moreover, most of the study participants used untreated source of drinking water (54.2%) and did not have a latrine at home (66.7%).

Prevalence, Intensity and Risk Factors of Soil-Transmitted Helminths

The overall STH prevalence was 32.3%. The prevalence of *A.lumbricoides*, Hookworm, and *T.trichuira* was found to be 24.3%, 8%, and 1%, respectively. The overall and species-wise prevalence showed statistically significant differences across districts. The overall prevalence of STH was 26.2%, 32.5%, 25.5%, and 42.4% in Maksegnit, Debark, Sanja, and Chuahit, respectively. On the other hand, the prevalence of *A.lumbricoides* and Hookworm was higher in Chuahit (41.3) and Sanja (24.3%), respectively, than any other districts (Table 1). Almost all (95%) of the infections were due to mono-infection.

Out of 254 school children who had STH infections, 204 (80.3%), and 47 (18.6%) were due to light and moderate intensity of infection, respectively. From the total of 191 study participants who were positive for *A. lumbricoides*, 138 (72.3%), 50 (26.2%), and 3(0.5%) were grouped as light, moderate and heavy infections, respectively. All Hookworm and *T. trichiura* infected children were due to light infections (Table 2).

In this study, participants whose age greater than 11 years (AOR, 12.9, 95% CI, 1.6–103.6), residing in Chuahit District (AOR, 3.9, 95% CI, 2.3–6.5), and using untreated water supply (AOR, 1.7, 95% CI, 1.1–2.7) were identified as potential risk factors for the transmission of STHs (Tables 3 and 4).

Discussion

The present study showed a high prevalence (32.3%) of STH infections among school-aged children in northwest Ethiopia regardless of the implementing school-based

Table 1 Overall and Species-Wise Prevalence of STHs Among School-Aged Children Across Districts in Northwest Ethiopia, 2019

Study Sites/No. of Participants (n)	Prevalence, n (%)			
	Overall	*A. lumbricoides*	Hookworm	*T. trichiura*
Maksegnit/n=172	45 (26.2)	45(26.2)	0(0)	0(0)
Debark/n= 83	27(32.5)	27(32.5)	0(0)	4(4.8)
Sanja/n=255	65(25.5)	5(2)	62(24.3)	1(0.4)
Chuahit/n=276	117(42.4)	114(41.3)	8(2.9)	3(1.1)
Total/n=786	254 (32.3)	191(24.3)	70(8.9)	8(1)
Chi-square (p-value)	21.22(<.001)	115.94(<0.001)	111.82(<.001)	9.56(0.007)

Abbreviation: STHs, soil-transmitted helminths.

Table 2 Intensity of STHs Infections Among School-Aged Children in Northwest Ethiopia, 2019

Parasite Species	Infection Intensity			
	Light n (%)	Moderate n (%)	Heavy n (%)	Mean Egg Count (Epg)
A. lumbricoides(n = 191)	138(72.3)	50(26.2)	3(0.5)	5938.79
Hookworm (n=70)	70(100)	0(0)	0(0)	264.51
T. trichiura(n = 8)	8(100)	0(0)	0(0)	198
Overall (n=*254)*	204 (80.3)	47 (18.6)	3 (1.1)	–

Abbreviation: Epg, eggs per gram.

Table 3 Binary Logistic Regression Analysis of Determinant Factors of STHs Infections Among School-Aged Children (n = 786) in Northwest Ethiopia, 2019

Variables		STHs Infection Status		COR (95% CI)	*P*-value
		Positive, n (%)	Negative, n (%)		
Sex	Male	124 (33.2)	250 (66.8)	1.076(0.798, 1.451)	0.632
	Female	130 (31.6)	282(68.4)	1	
Age	6–7	1(5.9)	16(94.1)	1	
	8–11	170 (31.7)	367(68.3)	7.411(0.975, 56.344)	0.051
	>11	83(35.8)	149(64.2)	8.913(1.161, 68.410)	0.006*
Study districts	Maksegnit	45(26.2)	127(73.8)	1.036(0.666, 1.611)	0.001*
	Debark	27(32.5)	56(67.5)	1.409(0.822, 2.415)	0.109
	Sanja	65(25.5)	190(74.5)	1	
	Chuahit	117(42.4)	159(57.6)	2.151(1.487, 3.112)	<0.001*
Grade	1–4	198(34.2)	381(65.8)	1.401(0.986, 1.991)	0.06
	5–8	56(27.1)	151(72.9)	1	
Source of water	Not treated	105(34.7)	198(65.3)	1.189(0.876, 1.613)	0.009*
	Treated	149(30.8)	334(69.2)	1	
Habit of eating raw vegetable	Yes	148(30.8)	332(69.2)	1	
	No	106(34.6)	200(65.4)	0.841(0.620, 1.141)	0.266
Latrine availability	Yes	160(30.5)	364(69.5)	1	
	No	94(35.9)	168(64.1)	0.786(0.574, 1.075)	0.029*
Hands wash after toilet	Yes	168(30.3)	386(69.7)	1	
	No	86(37.1)	146(62.9)	0.73(0.535,1.020)	0.066
Hand washing before eating	Yes	242(32.2)	510(67.8)	1	
	No	12(35.3)	22(64.7)	0.870(0.424, 1.787)	0.704
Habit of wearing shoe	Slipper	227(32.5)	472(67.5)	1.102(0.665, 1.826)	0.706
	Closed shoe	24(30.4)	55(69.6)	1	
	Never wear	3(37.5)	5(62.5)	0.802(0.190, 3.383)	0.763

Note: *Indicate variables with P < 0.05.
Abbreviation: COR, crude odds ratio.

periodic anti-helminthic treatment. Despite there is significant reduction in the overall prevalence of STH infections revealed from other previous reports (Jimma (45.6%),[24] Chincha (63%),[25] Tilili (44.2%),[26] and around Gilgel Gibe Dam (52.1%)),[27] our finding showed STH continues to afflict school children at a rate higher than the threshold recommended by the WHO (20%)[28] for implementation of mass deworming of school children in endemic areas.

Moreover, our finding is higher than other similar studies done in Ambo (12.6%),[29] Babile (0.47%),[30] and Dera district (20.9%).[31] This result discrepancy might be due to difference in the sample size of enrolled study

Table 4 Multivariate Logistic Regression Analysis of Determinant Factors of STHs Infections Among School-Aged Children (n = 786) in Northwest Ethiopia, 2019

Variables		STHs Infection Status		AOR (95% CI)	*P*-value
		Positive, n (%)	Negative, n (%)		
Age	6–7	1(5.9)	16(94.1)	1	
	8–11	170 (31.7)	367(68.3)	7.156(0.915, 55.974)	0.058
	>11	83(35.8)	149(64.2)	12.892(1.603, 103.682)	0.004*
Study districts	Maksegnit	45(26.2)	127(73.8)	2.112(1.150, 3.877)	0.337
	Debark	27(32.5)	56(67.5)	2.998(1.506, 5.967)	0.658
	Sanja	65(25.5)	190(74.5)	1	
	Chuahit	117(42.4)	159(57.6)	3.915(2.340, 6.549)	<0.001*
Availability of latrine	Yes	160(30.5)	364(69.5)		
		94(35.9)	168(64.1)	0.795(0.571,1.105)	0.172
Source of water	Not treated	105(34.7)	198(65.3)	1.74(1.108, 2.740)	0.018*
	Treated	149(30.8)	334(69.2)	1	

Note: *Indicate variables with *P* <0.05.
Abbreviation: AOR, adjusted odds ratio.

participants, the laboratory techniques carried out, specimen preparation, environmental and socio-economic factors that may account for the variation in the prevalence of these parasites. For instance, a study conducted in Babile applied the McMaster diagnostic technique, whereas the study in Ambo and Dera district used the formol-ether concentration technique. Thus, variation in the diagnostic technique's sensitivity might be the possible source of result discrepancies. Moreover, the transmission of STHs highly depends on a number of environmental factors (including the nature of soil type and climate) that influence the parasite survival, the extent to which the environment is contaminated with infectious egg/larvae and the amount of contact between susceptible host and contaminated soil.[32] So it might be the other possible source for the inconsistence of findings across study areas.

In this study, 80.3%, 18.6%, and 1.1% of the infected schoolchildren were within light, moderate, and heavy intensity of STHs infections. All infections caused by Hookworm and *T.trichiura* were under light infection category, whereas, 72.3%, 26.2%, and 0.5% of the infected children by *A.lumbricoides* were due to light, moderate, and heavy infection, respectively. Although the proportion of heavy and moderate infection intensity is relatively low in this study area, the existence of a significant number of children harboring light infections could serve as a potential source of re-infection for those who are already infected or new infections for other healthy children. Thus, this study calls for regular de-worming and other interventions in order to further decrease the prevalence until the targeted minimum threshold level of parasite intensity is determined for their elimination.

As evidenced from previously reported studies in many parts of the world, the prevalence of *A.lumbricoides* was also found to be the most prevalent STHs encountered in this study. This is supported with studies done in Ambo,[29] Chincha,[25] Tilili,[26] and Gondar.[33] The predominance of *A. lumbricoides* could be related with the extreme resistance of the eggs for harsh environments than the other STHs.[34] The second most prevalent was hookworm (8.9%). This data is lower than the studies conducted in Jimma, Wolaita, and Dera districts.[27,31,35] However, it is higher than the previous reports from Ambo, Babile, and Gondar Towns.[29,30,33] The prevalence of *T.trichiura* in the current study was 1% and similar results were reported from Wolaita and Ambo towns.[29,35] However, it is lower than previous studies reported from Gondar, Chincha, and Tilili towns.[25,26,32] Climatic variability, environmental factors, method and type of control measure implementation might have contributed for the infection rate differences across different regions. For instance, in the case of hookworm species climatic variability might ultimately favor the occurrence of the parasite due to its unique ability to undergo developmental arrest as dauer larvae in human tissues for the means of surviving the environmental extremes.[32,36,37] Moreover, the type of implementing control measures might affect the dominance of a certain worm within STHs due to worms having a unique susceptibility status for the applied anthelmintic drug as a preventive chemotherapy.

Moreover, the current study has identified potential risk factors for STHs infection. Accordingly, age, study sites (districts), and source of treated water were found to be significant predicators of STHs. Study participants, who had11 years and older were 13 times more likely to be infected by STHs than those who were <7 years old. This is probably related to prolonged exposure time as age increases. The prevalence of STH was significantly higher in Chuahit than any other districts. Students residing in Chuahit district were four times more likely to be infected by STH than those who were living in Sanja, Debark and Maksegnit. Debark and Maksegnit took the second and third ranks in terms of STH prevalence, while Sanja is the least. Variation of infection rates across the districts might be due to the difference in the weather condition of the study sites. Chuahit is located closer to a lake than other sites with more humid and warm climate. This may favor helminths ova for embryonation and ultimately enhance their transmission. Moreover, despite Sanja is a very dry hot area among our study sites and such weather condition may not be favorable for STH transmission; hookworm is relatively higher than other STHs may be due to the loamy soil type present in the district. The use of untreated water as a source of drinking and other domestic supply was almost two times more likely to be infected by STHs than their counterparts. This is due to the fact that untreated water might have been contaminated by human excreta which are potential for intestinal helminthiasis infection.

Conclusions

Approximately, one third of the study participants were infected with at least one STH species and this implies that they are still a health problem among school-aged children in Northwest Ethiopia. However, just over three-fourth of the infection intensity of STH was light. Age, residential district, and source of drinking water were associated with STHs infections. Thus, public health interventions such as provision of safe water supply, health education and de-worming programs should be regularly implemented in the study areas.

Limitation

The infection intensity of the common intestinal helminthiasis was determined by the examination of a single stool sample of each participant. Thus, intermittent egg excretion might have affected the sensitivity and accuracy of the egg count of the STHs. Thus, the findings should be interpreted with that limitation in mind.

Abbreviations

IPIs, intestinal parasitic infections; STH, soil-transmitted helminths; WHO, World Health Organization; SSA, Sub Saharan Africa.

Data Sharing Statement

All data generated or analyzed during this study are included in this manuscript. Other required data will be available from the corresponding author upon request.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from the ethical committee of School of Biomedical and Laboratory Sciences, University of Gondar (Ref. No. O/V/P/RCS/05/118/2017). Permissions were also obtained from North Gondar Zone and the district Health Departments. Moreover, parents/participant guardians who agreed that their child should be enrolled in the study were asked to provide a written informed consent, since the study participants were under the age of 18 years. Parents/legal guardians who were unable to read and write were asked to provide a thumbprint following the informed consent have been read clearly. Verbal assent was also sought from each study participant. Individuals who were found to be positive for STHs and other intestinal parasites were treated using anti-helminthic drug based on the standard treatment guideline.

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Author Contributions

All authors made a significant contribution to the conception, design and execution, acquisition of data, analysis and interpretation; took part in drafting the initial manuscript, revising it critically for final approval of the version to be published. All authors have agreed on the journal to which the article has been submitted and agreed to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no conflicts of interest for this work.

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