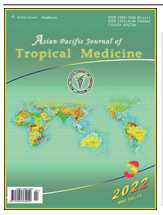

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Prevalence and risks of soil transmitted helminths among Ethiopian school children: A cross−sectional study

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ABSTRACT

Objective: To assess the prevalence and associated factors of soil transmitted helminths (STHs) among Endemata primary school in North West Ethiopia, 2021.

Methods: A cross-sectional study with 195 school children was conducted from May to July 2021 at Endemata primary school. The study participants were selected by using systematic random sampling technique. Stool samples were processed *via* direct wet mount and formol-ether concentration techniques. Data was entered by Epi-Dara version 3.1 and data analysis was done using SPSS version 20.0. Variables were considered to be statistically significant if $P<0.05$ at 95% confidence level.

Results: The overall prevalence of STHs was 10.8% (95% *CI* 7.1-16.0). The prevalence of *Ascaris lumbricoides*, hookworm and *Trichuris trichiura* were 5.6% (95% *CI* 3.1-9.9), 3.1% (95% *CI* 1.3-6.7) and 2.1% (95% *CI* 0.6-5.3), respectively. Grade 1-4 students were more likely to get infected with STHs as compared to grade 5-8 students (adjusted *OR* 4.7, 95% *CI* 1.3-16.6). Students who did not have latrines at their home were at higher risk to develop STHs infection comparing with those who had latrine at their home (adjusted *OR* 5.0, 95% *CI* 1.7-15.2). Similarly, the school children who did not wear shoes were more likely to be infected by STH parasite than those who did it (adjusted *OR* 6.3, 95% *CI* 1.9-20.7). The odds of being infected by STH parasites in children who did not trim their fingernails were 4.9 as compared to those who did it (adjusted *OR* 4.9, 95% *CI* 1.5-15.7).

Conclusions: The prevalence of STHs among Endemata primary school children was low. Student grade level, latrine availability, shoes wear and nail status were significantly associated with STHs infection. Therefore, we recommend policy makers and stakeholders to follow the integration of deworming with water, hygiene and sanitation as well as the consistent health education of school children to control and prevent STH infections.

KEYWORDS: Soil transmitted helminths; Prevalence; Associated factors; School children; Ethiopia

1. Introduction

Soil-transmitted helminthes (STHs) are a group of parasitic nematode worms that are categorized among neglected tropical diseases in the world's tropical and subtropical regions[1,2]. The common STH species of major public health challenge which cause severe morbidity among children in developing countries include

Significance

Although there are previous data on prevalence and associated risk factors of soiltransmitted helminths (STHs) infection among these high risk groups (school children) in Ethiopia, it is not well addressed in Ethiopia and it is also unknown in this study area. This study revealed lower grade students (grade 1-4) were more likely to get infected with STHs. In addition, students who did not have latrines at their home, did not wear shoes or did not trim their fingernails were more likely to develop STHs infection compared with those who did so.

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Ascaris (*A.*) *lumbricoides*, hookworms (*Ancylostoma duodenale* and *Necator americanus*) and *Trichuris* (*T.*) *trichiura*[3,4].

According to the latest estimates, more than 2 billion people in the world are infected with at least one species of STHs (due to *A. lumbricoides*: 1 billion, hookworm: 740 million and *T. trichiura*: 800 million)[1,5]. The highest prevalence occurs in areas where sanitation is inadequate and water supplies are unsafe[1,5]. These parasites affect more than a quarter of the world's population and contribute to a substantial burden of human disease and disability[6].

In sub-Saharan Africa, about 198, 173, and 162 million people are infected with hookworm, *A. lumbricoides*, and *T. trichiura*, respectively[7,8]. In Ethiopia, the number of people living in STHs endemic areas is estimated to be 81 million, comprising of 9.1 million preschool-age children, 25.3 million school-age children, and 44.6 million adults[9].

The STHs are transmitted through contact with parasite eggs or larvae that thrive in the contaminated warm and moist soil where sanitation is poor[10]. Therefore, infection with STHs occurs through accidental ingestion of *A. lumbricoides* and *T. trichiura* eggs and larval penetration of the skin by hookworm present in contaminated soil[10,11]. The transmission of STHs is higher in developing countries like Ethiopia where poverty, poor nutrition, inadequate sanitation, overcrowding, failure to put on foot wears, poor socioeconomic status, lack of clean drinking water, and minimal health care prevail[12,13].

There are limited data that show the prevalence and factors associated with STHs infection among the school children in the rural parts of Debre Markos town like Endemata primary school. Hence, this study will give an important clue for the stakeholders and policy makers on how to control and prevent STHs infection. Therefore, the aim of this study was to assess the prevalence and associated risk factors of STHs among Endemata primary school children, Ethiopia.

2. Materials and methods

2.1. Study design, period and area

This was a school based cross-sectional study conducted from May to July, 2021 at Endemta primary school in Debre Markos Town. The town is 297 km far from Addis Abeba which is the capital city of Ethiopia and 257 km far from Bihar Dar, the capital city of the Amhara region. The total numbers of students are 1 485 (685 males and 800 females) attending in the regular program.

2.2. Eligibility criteria

The school children aged between 6 up to 14 years who were willing to participate and provided sufficient stool samples were included while the students who had taken anti-helminth medication before two weeks of data collection were excluded.

2.3. Sample size determination

The sample size of this study was determined using single population proportion formula. Thus, the sample size was calculated by taking 13.2% previous study prevalence[14]. The final sample size was 195 by using the single proportion formula, 95% confidence interval (*CI*), and 5% margin of error with a 10% non-response rate.

2.4. Sampling technique

To select the study participants, the students were first stratified according to their educational level (grade 1 to 8). The sample size was proportionally allocated for each grade by dividing the number of students in each grade to the total number of students in the school, and then, the proportion was multiplied by the total sample size. Finally, the study participants were selected using a systematic random sampling technique by using a class roster as the sampling frame.

2.5. Independent variables

The studied independent variables which were adopted and modified from different literatures[15-17] included: sex, age, residence, student educational status (grade level), religion, family educational level, family marital status, family size, latrine availability, latrine floor wash, hand wash before meal, hand wash after latrine, shoe wear, clean environment, water source, playing with soil and finger nail status.

2.6. Data collection

An interviewer administered a structured questionnaire was used to collect data from school children. The questionnaire was administered to the study participants by the investigators in the school survey. The questionnaires were adopted and modified from study done in rural Debre Tabor, Ethiopia[14] and WHO guidelines[18] in English language and translated into local languages by interviewers in order to facilitate the understanding of interviewee. The adapted questionnaire was modified and contextualised to fit the local situation and research aim.

2.7. Laboratory method

After explaining the purpose of this study for the children, each student was given a stool collection container (clean plastic cup) and stool cup lid and instructed to bring his/her own fresh stool. Sample container was labeled when we receive the sample. The direct wet mount and formol-ther concentration method was used to detect STHs.

2.8. Wet mount method

In the wet mount method, a fresh stool sample (2 mg of stool) was putted on a glass slide with a wooden applicator stick. Next the stool sample was emulsified with a drop of physiological saline (0.85%), then covered with cover slide and examined under the microscope using the first 10× objective and then 40× objective to detect STHs[10].

2.9. Formol–ether concentration method

In formol-ether concentration (FEC) method, we added approximately 1 g of stool sample in a clean conical centrifuge tube containing 7 mL of 10% formol water. We filtered the suspension *via* a sieve in to 15 mL conical centrifuge tube. Next, 4 mL of diethyl ether was added to the formalin solution, and we centrifuged the content at 300 rpm for 1 minute. The supernatant was discarded and the smear was prepared using slide from the sediment. Finally, the prepared slide was examined under the microscope with magnification power of the first 10× objective and then 40× objective to detect STHs[10].

2.10. Data quality assurance

Prior to the data collection, training was given for data collectors about how to collect the data. The quality of reagents and instruments were checked by the principal investigator. The specimens were also checked for serial number, quantity, and procedures of collection. To assure the quality 10% of the sample was randomly selected and reexamined by an experienced laboratory technologist. The pretest was done among 5% of the total sample size (10 children) at Abima primary school in Debre Markos town. The supervisors frequently supervised the data collection process by checking the completeness of the required type of data. The data collection, transportation of the specimens and stool sample processing were performed by following the standard operational procedure. The questionnaires were checked for their completeness and consistency before data entry by the principal investigator.

2.11. Data analysis

Data was entered by Epi-Data version 3.1 and analyzed using Statistical Package for Social Sciences version 20. Descriptive statistics were used to determine the prevalence. The associations of independent variables with the STHs infections were calculated by univariate logistic regression. All variables with $P<0.25$ in the univariate analysis were candidates for multivariable logistic regression analysis to resolve the confounding effects. The association between independent variables and STHs infections were considered to be statistically significant if $P<0.05$ at 95% confidence level.

2.12. Ethical consideration and informed consent

Permission to conduct this study was approved by Debremarkos University College of Health Science, Department of Medical Laboratory Science Research, Ethical Review Committee with an approval number of D/M/L/S/211/02/12. The Endemata school director was informed about the aim and purpose of the research through the support letter which was given from our department. Informed consent was obtained from their parents/guardians and assent was obtained from each study child. To preserve the confidentiality, no personal identifiers were used on the data collection form. The collected data never accessed by a third person except the principal investigator, and was kept with a firm confidentiality. Study participants who were positive for any parasitic infections was linked to the nearby health center and treated accordingly.

3. Results

3.1. Socio–demographic characteristics of the study participants

Of 195 respondents, 111 (56.9%) were female. The age of respondents was (11.30±1.72) years with a minimum 8 and maximum 14 years. The majority (87.7%) of respondents lives in urban. One hundred fifty-four (79.0%) of the participants were Orthodox Christians followed by Muslims (36, 18.5%). Among study participants, 111 (56.9%) were below grade 1-4 and 84 (43.1%) were below grade 5-8 students. The majority (81.5%) of students' parents were married. Regarding family size 143 (73.3%) students' family contain 4-6 family members (Table 1).

Table 1. Socio-demographic characteristics of Endemata primary school children, North West, Ethiopia, 2021 (n=195).

Category	Frequency (%)
Sex	
Male	84 (43.1)
Female	111 (56.9)
Age group (years)	
6-10	91 (46.7)
11-14	104 (53.3)
Residence	
Urban	171 (87.7)
Rural	24 (12.3)
Student educational status	
Grade 1-4	111 (56.9)
Grade 5-8	84 (43.1)
Religion	
Orthodox	154 (79.0)
Muslim	36 (18.5)
Protestant	5 (2.6)
Family educational level	
Illiterate	46 (23.6)
Primary school	64 (32.8)
High school and above	85 (43.6)
Family marital status	
Married	159 (81.5)
Unmarried	10 (5.1)
Divorced	23 (11.8)
Widowed	3 (1.5)
Family size	
1-3 members	32 (16.4)
4-6 members	143 (73.3)
Greater than 7	20 (10.3)

3.2. Prevalence of STHs

Out of 195 stool specimens collected and examined, 21 (10.8%) of the children were infected individuals. Among the total infected individuals, 6 (3.1%) were positive for hook worm, 11 (5.6%) were positive for *A. lumbricoides* and 4 (2.1%) were positive for *T. trichiura* (Table 2).

Table 2. Prevalence of soil transmitted helminths among Endemata primary school children, North West, Ethiopia, 2021.

Parasite identified	Frequency	Percentage (%)	95% *CI*
Hookworm	6	3.1	1.3-6.7
Ascaris lumbricoides	11	5.6	3.1-9.9
Trichuris trichiura	4	2.1	0.6-5.3
Single infection	12	6.2	3.8-9.7
Double infection	6	3.1	1.3-6.7
Triple infection	3	1.5	0.3-4.6
STHs	21	10.8	7.1-16.0

Note: Single infection: Infection with only one parasite; Double infection: Infection with *Ascaris lumbricoides* and hookworm; Triple infection: Infection with *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm, STHs: At least one STH (*Ascaris lumbricoides*, and/or *Trichuris trichiura* and/or the hookworm).

Table 3. Bivariate logistic regression analysis of factors associated with soil transmitted helminths infection among Endemata primary school children, North West, Ethiopia, 2021.

Variables	Crude *OR* (95% *CI*)	*P*-value
Sex		
Female	2.537 (0.929-5.982)	0.071*
Male	1	
Age group (years)		
6-10	0.624 (0.250-1.556)	0.312
11-14	1	
Residence		
Urban	2.549 (0.839-7.747)	0.099*
Rural	1	
Student educational status		
Grade 1-4	3.702 (1.197-11.450)	0.023*
Grade 5-8	1	
Religion		
Orthodox	2.156 (0.227-20.491)	0.506
Muslim	2.000 (0.177-22.612)	0.575
Protestant	1	
Education level		
Illiterate	0.660 (0.228-1.905)	0.442
Primary school	1.397 (0.445-4.391)	0.567
High school and above	1	
Marital status		
Married	5.615 (0.447-66.161)	0.470
Unmarried	1.167 (0.074-18.346)	0.913
Divorced	2.375 (0.171-32.999)	0.519
Widowed	1	
Family size		
1-3 members	1.235 (0.246-6.203)	0.797
4-6 members	1.626 (0.423-6.245)	0.479
Greater than 7	1	
Latrine availability		
No	6.488 (2.453-17.157)	0.001*
Yes	1	
Latrine floor wash		
Yes	1	
No	0.479 (0.190-1.212)	0.120*
Hand wash before meal		
Yes	1	
No	1.484 (0.580-3.797)	0.410
Hand wash after latrine		
Yes	1	
No	1.042 (0.285-3.807)	0.951
Shoe wear		
Yes	1	
No	4.545 (1.767-11.690)	0.002*
Clean environment		
Yes	1	
No	2.810 (1.119-7.056)	0.028*
Water source		
Tap water	1	
Stream or river water	0.083 (0.083-1.379)	0.130*
Wall water	2.527 (0.729-8.766)	0.144*
Playing with soil		
Yes	0.477 (0.188-1.210)	0.119*
No	1	
Nail status		
Trimmed	1	
Untrimmed	7.936 (2.759-22.826)	0.001*

3.3. Factors associated STHs infection

In the bivariate analysis, *P*-value ⩽0.25 was used for the selection of variables in the multi variable analysis. Based on this, sex, residence, student grade level, family marital status, latrine availability, washing of latrine floor, shoe wear, clean environment, source of water, playing with soil and finger nail status were selected for the next multi variable logistic regression method (Table 3).

In the multivariable logistic regression analysis, student grade level, latrine availability, shoe wear and finger nail status were significantly associated with STH infections among school children (Table 4). Therefore, grade 1-4 students weremore likely to get infected with STHs as compared to grade 5-8 students (adjusted *OR* 4.645, 95% *CI* 1.301-16.591). Alike, those students who did not have latrines at their home were at higher risk to develop STHs infection as those students who had latrine at their home (adjusted *OR* 5.010, 95% *CI* 1.649-15.220). Similarly, the school children who did not wear shoes weremore likely to be infected by STH parasite than those who did it (adjusted *OR* 6.299, 95% *CI* 1.913-20.739). The odds of being infected by STH parasites in those children who did not trim their fingernails were 4.871 as compared to those who did it (adjusted *OR* 4.871, 95% *CI* 1.508-15.727).

4. Discussion

The overall prevalence of STHs in the present study was 10.8%. The prevalence of STHs was similar with previous result obtained (13.2%) in rural Debre Tabor[14], 12.6% in Ambo town[19] and 9.5% in Gurage zone[20]. In the current study, the prevalence of STHs infection observed was lower than the prevalence among school aged children conducted in various areas of Ethiopia (23.3% in Butajira, 88.3% in Wondo Genet and 35.2% in Dembia district)[21–23]; 40.7% in Kenya[24] and 22.9% in China[25]. On the other hand, the prevalence of STHs in Babile town, Ethiopia (0.47%)[26] was lower than the present study. The variation might be: study time, diagnostic method used to detect the parasite, genetic variation, sanitation, type of weather, and altitude[27,28].

In the present study, the predominant STH encountered was *A. lumbricoides* (5.6%), this result was comparable with studies done so far in Ethiopia[23,29,30] and in Nigeria[31], followed by hookworm (3.1%) and *T. trichiura* (2.1%). The prevalence of *A. lumbricoides* and *T. trichiura* in this study was similar to the study conducted in Debre Tabor[14] with a prevalence of 8.2% and 1.2%, respectively. Hookworm accounted 3.1% prevalence in the present study which was lower than 8.2% in North West Ethiopia[32], 7.6% Ethiopian national prevalence[33] and 25.2% in Tanzania[34]. Moreover, *T. trichiura* is another STH with 2.1% and it was lower than previous

Table 4. Multivariable logistic regression analysis of factors associated with soil transmitted helminths infection among Endemata primary school children, North West, Ethiopia, 2021.

Variables	Crude *OR* (95% *CI*)	*P*-value	Adjusted *OR* (95% *CI*)	*P*-value
Sex				
Male	1		1	
Female	2.537 (0.929-5.982)	0.071	1.467 (0.328-6.55)	0.616
Residence				
Urban	2.549 (0.839-7.747)	0.099	12.712 (0.469-344.912)	0.131
Rural	1		1	
Grade				
1-4	3.702 (1.197-11.450)	0.023	4.645 (1.301-16.591)	0.018*
5-8	1		1	
Latrine availability				
Yes	1		1	
No	6.488 (2.453-17.157)	0.001	5.010 (1.649-15.220)	0.004*
Latrine floor wash				
Yes	1		1	
No	0.479 (0.190-1.212)	0.120	0.635 (0.124-3.240)	0.585
Shoe wearing				
Yes	1		1	
No	4.545 (1.767-11.690)	0.002	6.299 (1.913-20.739)	0.002*
Clean environment				
Yes	1		1	
No	2.810 (1.119-7.056)	0.028	1.108 (0.210-5.840)	0.904
Water source				
Tap water	1		1	
Stream or river water	0.083 (0.083-1.379)	0.130	0.302 (0.064-1.428)	0.131
Wall water	2.527 (0.729-8.766)	0.144	2.409 (0.520-11.157)	0.261
Play with soil	0.477 (0.188-1.210)	0.119	0.277 (0.059-1.294)	0.103
Finger nail				
Trimmed	1		1	
Untrimmed	7.936 (2.759-22.826)	0.001	4.871 (1.508-15.727)	0.008*

studies conducted in Ethiopia; 23.1% in Mendera Elementary School[35], 47.6% in Jimma town[36], and 5.9% national prevalence of *T. trichiura*[33]. This difference might be due to differences in diagnostic methods, environmental sanitation, geographical location of study area and study time. In addition, socioeconomic status of the households and water supply also contribute to the differences in the prevalence and distribution of these STH parasites, although this needs to be verified in more extensive follow-up studies.

In the present study, STHs infection was associated with the educational level of students, availability of latrine at home, and finger nail trimming status. These findings were in line with the study conducted in Tach Armachiho district[37] and Motta town[38]. Another factor which was associated with STH infection in this study was walking barefooted. This might be due to most children's engagement in agricultural activities to help their parents, which in turn, exposed them to infective stages of the STH parasite[39]. Hookworm infection was higher in those children did not wear shoe. This indicated that wearing shoes have great value in preventing hookworm infection[12].

According to the Ethiopian national neglected tropical disease master plan 2016-2020, the prevalence of STH is low if the prevalence is <20%. Therefore, the prevalence of STHs among Endemata primary school children was low. *A. lumbricoides* was the predominated, followed by the hookworm. Associated factors, including: student grade level, latrine availability at home, shoe wear and finger nail status were significantly associated with STH infection. Hence, we recommend policy makers and stake holders to follow the integration of deworming with water, hygiene and sanitation as well as the consistent health education of school children to control and prevent STH infections[40]. Latrine availability and properly used in the community are also important for the reduction of STHs prevalence below the percentage find in this study area. In addition, the risk factors of STH infections among school children should be critically evaluated by the health staffs especially by the health extension workers.

Conflict of interest statement

The authors declare that they have no competing interests

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Authors' contributions

A.F developed the theoretical formalism, performed the analytical calculations and performed the numerical simulations. He, also, critically reviewed the manuscript. B.M facilitated the data collection and supervision, laboratory test analysis and drafted the manuscript. F.B, G.T, G.A, E.T and G.A contributed to sample collection, data organization and Laboratory test.

References

[1] World Health Organization. *Eliminating soil-transmitted helminthiases as a public health problem in children: Progress report 2001-2010 and strategic plan 2011-2020.* [Online]. Available from: https://apps.who.int/iris/handle/10665/44804. [Accessed on 22 October 2021].

[2] Abdeltawabi MS, El Seddik N, Salem HK. World wide epidemiology of helminths infection. In: *Human helminthiasis.* London: IntechOpen; 2017, p. 3-16.

[3] Ohuche IO, Ayuk AC, Ubesie AC, Onu JU, Ibe BC. Soil-transmitted helminthiasis: A neglected tropical disease among urban slum dwelling school-aged children of a sub-Saharan African city. *Niger Postgrad Med J* 2020; **27**(3): 184.

[4] Uneke C. Soil transmitted helminth infections and schistosomiasis in school age children in sub-Saharan Africa: Efficacy of chemotherapeutic intervention since World Health Assembly Resolution 2001. *Tanzan J Health Res* 2010; **12**(1): 86-99.

[5] Parija SC, Chidambaram M, Mandal J. Epidemiology and clinical features of soil-transmitted helminths. *Trop Parasit* 2017; **7**(2): 81.

[6] Pullan RL, Smith JL, Jasrasaria R, Brooker SJ. Global numbers of infection and disease burden of soil transmitted helminth infections in 2010. *Parasit Vectors* 2014; **7**(1): 1-19.

[7] Hotez PJ, Kamath A. Neglected tropical diseases in sub-Saharan Africa: Review of their prevalence, distribution, and disease burden. *PLoS Negl Trop Dis* 2009; **3**(8): e412.

[8] Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J. Schistosomiasis and water resources development: Systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect Dis* 2006; **6**(7): 411-425.

[9] Ababa A. *Federal democratic republic of Ethiopia ministry of health. 2003.* [Online]. Available from: http://africanchildforum.org/clr/policy%20per%20country/ethiopia/ethiopia_nutrition_2003_en.pdf. [Accessed on 22 October 2021].

[10] Williams J. District laboratory practice in tropical countries. *Trans R Soc Trop Med Hyg* 2000; **94**(2): 231.

[11] Gillespie S, Pearson RD. *Principles and practice of clinical parasitology.* New Jersey: John Wiley & Sons; 2003.

[12] Bethony J, Brooker S, Albonico M, Geiger SM, Loukas A, Diemert D, et al. Soil-transmitted helminth infections: Ascariasis, trichuriasis, and hookworm. *Lancet* 2006; **367**(9521): 1521-1532.

[13] Chinenye GN, Eze N, Nduka FO. Geohelminth infections and associated

risk factors among children living in selected shanty (Batcher) settlements in Port Harcourt Metropolis, Rivers State, Nigeria. *Int J Trop Dis Health* 2018; **29**(1): 1-8.

[14]Workineh L, Kiros T, Damtie S, Andualem T, Dessie B. Prevalence of soil-transmitted helminth and *Schistosoma mansoni* infection and their associated factors among Hiruy Abaregawi primary school children, rural Debre Tabor, North West Ethiopia: A cross-sectional study. *J Parasitol Res* 2020. doi: https://doi.org/10.1155/2020/2521750.

[15]Tulu B, Taye S, Amsalu E. Prevalence and its associated risk factors of intestinal parasitic infections among Yadot primary school children of South Eastern Ethiopia: A cross-sectional study. *BMC Res Notes* 2014; **7**(1): 1-7.

[16]Alemayehu B, Tomass Z. Prevalence of intestinal helminthiasis and associated risk factors among school children in Dawro Zone, Southern Ethiopia. *J Biol Agric Healthc* 2015; **15**(11): 76-82.

[17]Damtie D, Sitotaw B, Menkir S, Kerisew B, Hussien K. Human intestinal parasitic infections: Prevalence and associated risk factors among elementary school children in Merawi Town, Northwest Ethiopia. *J Parasitol Res* 2021. doi: https://doi.org/10.1155/2021/8894089.

[18]World Health Organization. *Helminth control in school–age children: A guide for managers of control programmes. 2011.* [Online]. Available from: https://apps.who.int/iris/handle/10665/44671. [Accessed on 22 October 2021].

[19]Samuel F, Demsew A, Alem Y, Hailesilassie Y. Soil transmitted helminthiasis and associated risk factors among elementary school children in ambo town, western Ethiopia. *BMC Public Health* 2017; **17**(1): 1-7.

[20]Weldesenbet H, Worku A, Shumbej T. Prevalence, infection intensity and associated factors of soil transmitted helminths among primary school children in Gurage zone, South Central Ethiopia: A cross-sectional study design. *BMC Res Notes* 2019; **12**(1): 1-6.

[21]Shumbej T, Belay T, Mekonnen Z, Tefera T, Zemene E. Soil-transmitted helminths and associated factors among pre-school children in Butajira Town, South-Central Ethiopia: A community-based cross-sectional study. *PLoS One* 2015; **10**(8): e0136342.

[22]Samuel F, Degarege A, Erko B. Efficacy and side effects of albendazole currently in use against *Ascaris*, *Trichuris* and hookworm among school children in Wondo Genet, southern Ethiopia. *Parasitol Int* 2014; **63**(2): 450-455.

[23]Alemu A, Tegegne Y, Damte D, Melku M. *Schistosoma mansoni* and soil-transmitted helminths among preschool-aged children in Chuahit, Dembia district, Northwest Ethiopia: Prevalence, intensity of infection and associated risk factors. *BMC Public Health* 2016; **16**(1): 1-9.

[24]Davis SM, Worrell CM, Wiegand RE, Odero KO, Suchdev PS, Ruth LJ, et al. Soil-transmitted helminths in pre-school-aged and school-aged children in an urban slum: A cross-sectional study of prevalence, distribution, and associated exposures. *Am J Trop Med Hyg* 2014; **91**(5): 1002.

[25]Wang X, Zhang L, Luo R, Wang G, Chen Y, Medina A, et al. Soil-transmitted helminth infections and correlated risk factors in preschool and school-aged children in rural southwest China. *PLoS One* 2012; **7**(9): e45939. doi: 10.1371/journal.pone.0045939.

[26]Tefera E, Mohammed J, Mitiku H. Intestinal helminthic infections among elementary students of Babile town, eastern Ethiopia. *Pan Afr Med J* 2015. doi: 10.11604/pamj.2015.20.50.5251.

[27]Mokua D, Shivairo R, Muleke C, Mukabane D, Oswe M, Kumba J. Soil transmitted helminthes prevalence among pre-school age children in Elburgon Municipality, Kenya. *J Biol Agric Healthc* 2014; **4**(21): 36-41.

[28]Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J. Helminth infections: The great neglected tropical diseases. *J Clin Invest* 2008; **118**(4): 1311-1321.

[29]Ayalew A, Debebe T, Worku A. Prevalence and risk factors of intestinal parasites among Delgi school children, North Gondar, Ethiopia. *J Parasitol Vector Biol* 2011; **3**(5): 75-81.

[30]Abossie A, Seid M. Assessment of the prevalence of intestinal parasitosis and associated risk factors among primary school children in Chencha town, Southern Ethiopia. *BMC Public Health* 2014; **14**(1): 1-8.

[31]Egwunyenga OA, Ataikiru DP. Soil-transmitted helminthiasis among school age children in ethiope East local government area, delta state, Nigeria. *Afr J Biotechnol* 2005; **4**(9): 938-941.

[32]Endris M, Tekeste Z, Lemma W, Kassu A. Comparison of the Kato-Katz, wet mount, and formol-ether concentration diagnostic techniques for intestinal helminth infections in Ethiopia. *ISRN Parasitol* 2013; **2013**: 180439. doi: 10.5402/2013/180439.

[33]Leta GT, Mekete K, Wuletaw Y, Gebretsadik A, Sime H, Mekasha S, et al. National mapping of soil-transmitted helminth and schistosome infections in Ethiopia. *Parasit Vectors* 2020; **13**(1): 1-13.

[34]Mazigo H, Ambrose E, Zinga M, Bahemana E, Mnyone L, Kweka E, et al. Prevalence of intestinal parasitic infections among patients attending Bugando Medical Centre in Mwanza, north-western Tanzania: A retrospective study. *Tanzan J Health Res* 2010; **12**(3): 178-182.

[35]Tefera E, Belay T, Mekonnen SK, Zeynudin A, Belachew T. Prevalence and intensity of soil transmitted helminths among school children of Mendera Elementary School, Jimma, Southwest Ethiopia. *Pan Afr Med J* 2017; **27**: 88.

[36]Debalke S, Worku A, Jahur N, Mekonnen Z. Soil transmitted helminths and associated factors among schoolchildren in government and private primary school in Jimma Town, Southwest Ethiopia. *Ethiopian J Health Sci* 2013; **23**(3): 237-244.

[37]Yimer M, Abera B, Mulu W. Soil transmitted helminths and *Schistosoma mansoni* infections in elementary school children at Tach Armachiho district, North-west Ethiopia. *J Appl Sci Res* 2014; **2**(2): 43-53.

[38]Asemahagn MA. Parasitic infection and associated factors among the primary school children in Motta town, western Amhara, Ethiopia. *Am J Public Health Res* 2014; **2**(6): 248-254.

[39]Abera B, Alem G, Yimer M, Herrador Z. Epidemiology of soil-transmitted helminths, *Schistosoma mansoni*, and haematocrit values among schoolchildren in Ethiopia. *J Infect Dev Ctries* 2013; **7**(3): 253-260.

[40] Labana RV, Romero VA, Guinto AM, Caril AN, Untalan KD, Reboa AJ, Sandoval KL, Cada KS, Lirio GC, Bernardo IA, Arocha LM, Dungca JZ. Prevalence and intensity of soil-transmitted helminth infections among school-age children in the Cagayan Valley, the Philippines. *Asian Pac J Trop Med* 2021; **14**: 113-121.