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Intestinal schistosomiasis in remote areas of Southwest Ethiopia, a target region for large-scale mass drug administration

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As 2030 approaches, the World Health Organization's due date for ending intestinal schistosomiasis as a public health problem in all endemic areas, understanding the current trends in the burden of schistosomiasis among schoolchildren in endemic areas is critical for monitoring the progress, identifying areas for improvement, and developing strategies to plan for instant response to mitigate the burden of schistosomiasis. From February to April of 2023, 328 students from three primary schools in Southwest Ethiopia participated in an institution-based cross-sectional study in the detection of *Schistosoma mansoni*. Intestinal schistosomiasis was identified among 242 school children, with a rate of infection of 73.8% (95% CI: (64.8–83.4%)). The rate of infection was higher among study participants aged between 10 and 13 years [AOR = 1.93, 95% CI: (1.1, 3.44). About 75% of the male participants were infected with *Schistosoma mansoni* [AOR = 0.83, 95% CI (0.49, 1.41). Nearly half (48.1%) of the *S. mansoni* infections among study participants were identified as heavy infections. More than half of the male study participants (50.3%) infected with *Schistosoma mansoni* had heavy infection intensity. Of the total female schoolchildren infected with *Schistosoma mansoni*, about 44.4% had a heavy infection. The prevalence and intensity of infection of *Schistosoma mansoni* in the study area are significantly noticeable, raising doubts on the effectiveness of the interventional programs or pin-points possible re-infection. Strategies to end the disease as a public health threat, mainly in remote and endemic areas, should consider novel integrated strategies targeting the life cycle of schistosomes besides the large-scale mass drug administration.

Keywords *Schistosoma mansoni*, Prevalence, Intensity, Southwest Ethiopia, Schoolchildren

Schistosomiasis is one of the prevalent neglected tropical diseases infecting millions of people globally, with an estimated 140 million individuals infected with a common schistosome species[1]. Sub-saharan Africa is the region with the highest rate of infections with common schistosome species, *S. mansoni* and *S. haematobium*, causing intestinal schistosomiasis and urogenital schistosomiasis, respectively[2].

The control approach to schistosomiasis is repeated preventative chemotherapy, which treats a segment of the population usually children, without first requiring a parasitological examination[3,4]. Besides preventive chemotherapy, an integrated control mechanism, which targets the life cycle should be done in parallel to mitigate the impact of schistosomiasis[3].

The World Health Organization (WHO) set a program for the year 2021–2030, targeting the elimination of human schistosomiasis as a community problem by 2030 and the interruption of its transmission in endemic areas[5].

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However, the absence of precise data regarding the identification of transmission foci (lack of clear geographical boundaries), delays in drug delivery, occurrence of disease outbreaks, and negative perceptions towards the drug in line seen in many developed countries are the existing challenges in prevention of schistosomiasis in endemic areas[6–8]. Furthermore, the COVID-19 pandemic in 2021 and efforts to lessen its impacts negatively affected the provision of neglected tropical disease interventions and the treatment coverage for schistosomiasis[5].

Ethiopia is among the Sub-Saharan African nations where schistosomiasis among schoolchildren has been common in the past ten years, with a prevalence rate as high as 89.9%[9,10]. Nonetheless, data from recent research in some parts of the country indicate that Ethiopia is seeing a decline in the prevalence of schistosomiasis[11–13]. This may result from the interventions taken through the MDA program[14]. However, the palliating magnitude of intestinal schistosomiasis in some districts of the country creates a misleading sense of the decreasing burden of schistosomiasis in endemic areas too. Nevertheless, schistosomiasis continues to impact a sizable portion of the children living in endemic regions in Ethiopia[15]. The COVID-19 pandemic[5], usage of open water bodies for bathing[16], irrigation programs[17], insufficient coverage of curative treatment[18], and socioeconomic status[19], are the potential causes of extending the torment of the populations in Ethiopia and in turn contributing to delay the WHO strategy to eliminate schistosomiasis as a community problem in endemic areas.

Evidence showed that Ethiopia has been implementing a large-scale nationwide MDA program against schistosomiasis since 2015, targeting 17 million schoolchildren[20]. However, the magnitude of *S. mansoni* infection among schoolchildren in remote areas of the country has not been well elaborated since the implementation of a large-scale MDA program. Additionally, the surveillance program to monitor the effectiveness of the ongoing large-scale nationwide MDA program is not applicable in remote areas. Although some studies were conducted regarding intestinal schistosomiasis among school children[21,22], those studies didn't consider the resource-limited areas and their focus on large-scale MDA programs is negligible. Hence, there was a clear importance to conducting this study as it overcame the limitations of the previous studies. Therefore, this study was aimed at assessing the magnitude and intensity of infection of *S. mansoni* among schoolchildren in Southwest Ethiopia, one of the target regions for the large-scale MDA program, to contribute to the progress evaluation of large-scale MDA program and supplement the WHO strategy to eliminate schistosomiasis as a public health problem in all endemic areas.

Materials and methods

Study setting

Children from three primary schools, Biftu Ayyana, Shimal Tokke, and Urji Oromiya primary schools in remote areas of Southwest Ethiopia; have participated in the study, which was carried out between February and April of 2023. The region has 1450 m elevation above sea level, with a long dry season from November to April and a rainy season from May to September. It is characterized by a warm climate with mean temperatures between 1138 and 1690 mm. The mean yearly rainfall is ranging between 1138 and 1690 mm. The study area has a free-flowing river that the residents frequently use for daily life, which could be a potential risk factor for infection with *S. mansoni*. There are 8 primary schools present in the study area. The MDA program has been implemented in all primary schools present in the study area with a participation rate of 98.2% (Fig. 1).

Study design and sample size

A multi-centered cross-sectional study was carried out to assess the magnitude and intensity of infection of *S. mansoni* among school children from selected primary schools in the Oromia region; Biftu Ayyana, Shimal Tokke, and Urji Oromiya. A single population proportion formula calculated the minimum representing sample size. Considering the 28.7% prevalence of *S. mansoni* infection from the previous study[11], a 95% confidence level, and a 5% margin of error the minimum sample size was computed to be 313. With a 5% non-response rate, 328 children made up the final sample.

Sampling technique

Out of 8 primary schools present in the study area, three schools were randomly selected. The class registrations of all schools having children's lists from grades 1 through 6, aged from six to seventeen years were used as sampling frames. The minimum sample size was proportionally allocated to each of the three primary schools. Accordingly, 149 students from Biftu Ayyana Primary School, 76 students from Shimal Tokke Primary School, and 103 students from Urji Oromiya Primary School were randomly selected. The background of the study was explained to the children and the school directors.

Field and laboratory procedures

The study participants were given a clean plastic sheet with a wooden applicator stick and requested to provide the stool sample. Two Kato-Katz slides were prepared for each child using a 41.7 mg template and sent to Mattu University's Medical Parasitology Laboratory. The Kato-Katz smear technique was used for the qualitative analysis and the quantification of *S. mansoni* eggs. The mean number of eggs counted in both Kato-Katz slides was multiplied by 24 to get the intensity of *S. mansoni* infection. A stool specimen from each subject was deemed positive for *S. mansoni* infection when an *S. mansoni* egg was found during a microscopic examination. Conversely, the specimen is considered negative for *S. mansoni* infection when the microscopic examination didn't reveal any eggs of *S. mansoni*. The intensity of infection was determined using WHO criteria[23] and classified as light (1–99 EPG), moderate (100–399 EPG), and heavy (>400 EPG). The school directors were interviewed for socio-demographic data, MDA participation, and possible water sources in the community using a structured questionnaire.

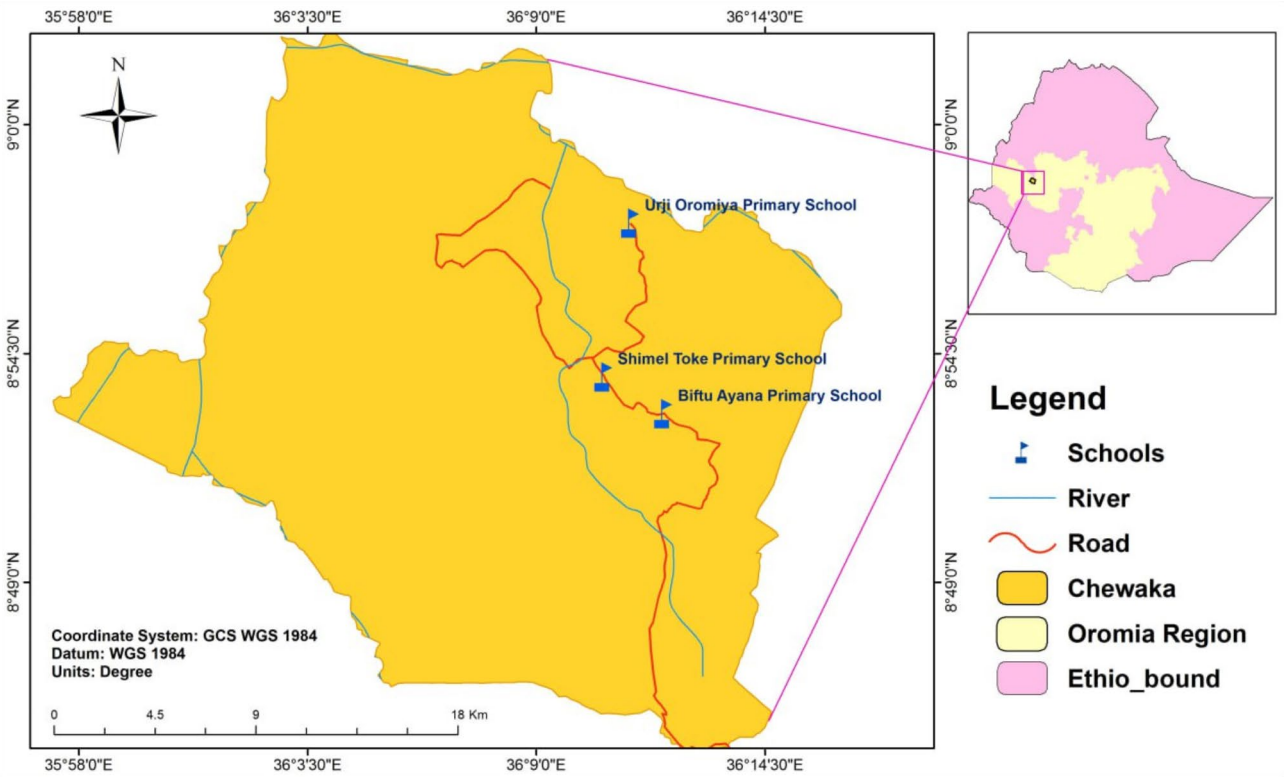

Fig. 1. Geographical map indicating the study area in relation to the major water body, in remote areas of Southwest Ethiopia: geospatial data (vector data and GPS points) generated using ArcGIS version 10.5 (Esri, California, USA, 2016. https://www.esri.com).

Data processing and statistical analysis

Data entry was done using Epi-data version 3.1 and exported to IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, NY, USA) for statistical analysis. Descriptive statistics were computed to determine the prevalence of *schistosoma* infections and the frequencies of other variables. The possible association between the sociodemographic factors and Intestinal schistosomiasis was indicated by the odds ratio (OR) at a 95% confidence interval (CI). A p-value of ≤ 0.05 was considered indicative of a statistically significant association.

Results

Socio-demographic characteristics of study participants

A total of 328 schoolchildren (62.2% males and 37.8% females) with ages ranging from 6 up to 17 years have participated in the study. Among these, 45.4% were from Biftu Ayana Primary School, 23.2% were from Shimal Toke Primary School, and 31.4% were from Urji Oromiya Primary School. Most of the study participants, (44.7%), were aged 10–13 years; followed by 14–17 years old (40.5%) and 6–9 years old (16.2%) (Table 1).

Prevalence of intestinal schistosomiasis

Intestinal schistosomiasis was detected among 242 study participants, with a 73.8% rate of infection (95% CI: (64.8–83.4%)). The infection rate was high among study participants aged between 10 and 13 years [AOR = 1.93, 95% CI: (1.1, 3.44). About 75% of the male participants were found positive for intestinal schistosomiasis [AOR = 0.83, 95% CI (0.49, 1.41). The prevalence is higher among schoolchildren at Biftu Ayana Primary School [AOR = 0.34, 95% CI: (0.17, 0.68)] than the other two primary schools (Table 1).

Intensity of infection of *S. mansoni*

Nearly half (48.1%) of the *S. mansoni* infections among study participants were identified as heavy infections. Over half of the male study participants (50.3%) infected with *S.mansoni* had heavy infection intensity. Of the total female schoolchildren infected with *S.mansoni*, about 44.4% were with a heavy infection. The majority of heavy infections were detected among study participants of Urji Oromia Primary School (52.27%) (Table 2).

Discussion

Ethiopia has been implementing a large-scale nationwide MDA against soil-transmitted helminths and schistosomiasis, targeting 17 million school-aged children. The timely update on intestinal schistosomiasis in a region where a large-scale MDA program targets is substantial in the evaluation of the implementation, coverage, and/or progress of the interventional programs. Hence, this study paid attention to the magnitude and

Variables	Category	N	*S. mansoni infection*		COR, 95%(CI)	AOR, 95%(CI)
			Positive	Prevalence %,(95%CI)		
Age	6–9	53	37	69.8(45.6–94.0)	1.09(0.54–2.20)	0.81(0.38–1.73)
	10–13	142	112	78.8(65.6–91.9)	1.61(0.93–2.77)	1.93(1.1–3.44)
	14–17	133	93	69.9(54.6–85.2)	1	1
Gender	Male	204	152	75.0(63.3–86.6)	1.1(0.67–1.82)	0.83(0.49–1.41)
	Female	124	90	73.4(58.2–88.6)	1	1
Schools	Biftu Ayyana	149	107	71.8(57.6–85.9)	0.43(0.23–0.83)	**0.34(0.17–0.68)***
	Shimal Tokke	76	47	61.8(40.4–83.2)	0.29(0.14–0.6)	0.24(0.11–0.51
	Urji Oromia	103	88	85.4(72.0-98.7)	1	1

Table 1. Prevalence of *S.mansoni* in age, sex, and school among study participants in remote areas of Southwest Ethiopia ($N = 328$). N, number of study participants; 1, reference category; *, p-value < 0.05; Numbers in bold font represent significant association with *S. mansoni* infections. *CI* confidence interval, *COR* crude odds ratio, *AOR* adjusted odds ratio.

Variables	Category	Intensity of infection			
		Light *n* (%)	Moderate *n* (%)	Heavy *n*(%)	AM (95% CI)
Age	6–9	6 (16.2)	12 (32.4)	19 (51.4)	818.4 (805.2-831.6)
	10–13	16 (14.3)	43 (38.4)	53 (47.3)	665.6 (652.5-678.7)
	14–17	15 (16.1)	34 (36.6)	44 (47.3)	682.6 (667.3-697.9)
Gender	Male	22 (13.5)	54 (35.5)	76 (50)	708.4 (696.7-720.1)
	Female	14 (15.6)	36 (40)	40 (44.4)	666.7 (643.4–690.0)
Schools	Biftu Ayyana	17 (15.9)	39 (36.4)	51 (47.7)	590.6 (575.4-605.8)
	Shimal Tokke	9 (19.2)	19 (40.4)	19 (40.4)	574.5 (560.6-588.4)
	Urji Oromia	10 (11.4)	32 (36.4)	46 (52.2)	891.2 (867.0-915.4)
Overall		36 (14.9)	90 (37.2)	116 (47.9)	694.09 (681.6–706.6)

Table 2. Infection intensity of *S.mansoni* among schoolchildren from three primary schools in remote areas of Southwest Ethiopia ($N = 242$). *n* number, *N* total number of positive cases. *AM* arithmetic mean.

intensity of infection of intestinal schistosomiasis among schoolchildren in remote areas of southwest Ethiopia where a long-term MDA program is being implemented.

This study revealed the magnitude of *S. mansoni* among schoolchildren in the study area post-MDA program with more than 98% rate of participation was 73.8%. Despite the high MDA participation rate of the school children, the prevalence of intestinal schistosomiasis post-MDA program in the study area was higher as compared to the other studies conducted in different parts of the world after MDA interventions[24,25]. The higher prevalence of intestinal schistosomiasis post-MDA intervention from this study could be because of the endemicity of the disease in the district, the geographical remoteness of the district which may affect the smooth and regular implementation of the complementary interventions, the presence of aquatic environments in the area that serve as the permanent reservoir of snails, frequency of drug administration, drug efficacy/ treatment failure, and awareness towards intestinal schistosomiasis among schoolchildren.

The higher prevalence of the disease post-MDA program in the study area could also be because of the possibility of re-infection since there was sufficient time for the parasite (11 months since the last MDA) to undergo its lifecycle and cause re-infection.

Additionally, though the long-term nationwide MDA program taking place in the country is targeting the susceptible segment of the population, the in-involvement of the other community members can also contribute to the reduced effectiveness of the interventional program.

Community members who are not the target population for the preventive chemotherapy and are infected with *S. mansoni* could play a role in the life cycle of schistosome and contribute to high prevalence. Moreover, socioeconomic status and other associated factors in line seen in other regions[17–19], can also be a reason for the high prevalence and intensity of infection registered in the study area.

On the other hand, though it is not significant, our study revealed that male study participants had a higher rate of infection with *S. mansoni* than females, which is similar to other studies[26,27]. Male students were more commonly known to participate in outdoor activities, increasing the possibility of higher water contact as they are more active and often engage in various agricultural works in developing countries, which is likely linked to the higher frequency and higher intensity of infection.

Additionally, the majority of infections were detected among schoolchildren aged 10–13, which is consistent with the studies in northern Ethiopia[28,29], southwest Ethiopia[30], and Tanzania[31]. This might be because of a lack

of awareness regarding intestinal schistosomiasis as compared to higher age groups and frequent contact with aquatic environments as compared to lower age group children.

The odds of infection with intestinal schistosomiasis are higher among Biftu Ayana Primary Schools than the rest two primary schools. The possible reason behind this can be the proximity of Biftu Ayana Primary Schools to the aquatic environment harboring intermediate hosts.

This study also revealed nearly half of the schoolchildren found positive for intestinal schistosomiasis were with a heavy infection intensity. However, this finding has a variation as compared to other studies conducted in southwest Ethiopia[32], Kenya[33], Tanzania[34], and Madagascar[35] where light intensity of infection has been detected. The disparity in infection intensity between various studies could be because of the distance of water bodies from residential areas, which determines the frequency of contact with aquatic environments, variation in water-contact behavior, awareness of the schoolchildren, and level of effectiveness and applicability of the deworming program in the district.

Limitations of the study

The study couldn't identify the possible risk factors behind the high prevalence of intestinal schistosomiasis in the study area because of the nature of the study design. On the other hand, due to a lack of resources, the negative kato-katz slides were not considered for further PCR examination.

Conclusion and recommendation

It has been elucidated by this study that about three-quarters of schoolchildren were positive for intestinal schistosomiasis and a significant infection intensity was documented in the preventive chemotherapy era despite the high MDA participation rate in the study area, which counteracts the WHO strategy to eliminate the parasite in 2030. The palliating prevalence of *Schistosoma mansoni* in some districts of the country also created a false sense of the reduced burden of intestinal schistosomiasis in endemic areas. The high prevalence and intensity of intestinal schistosomiasis infection in the study area either raise doubts about the effectiveness of the interventional programs or highlight the possibility of re-infection. Endemic and remote areas should be paid special consideration for the intervention. Additionally, the delay between successive drug administration periods should be reduced to minimize the possibility of re-infection. Further consideration of the novel preventive interventions in remote areas targeting the life cycle of schistosomes accompanied by environmental sanitation and intermediate host management is to be extended to remote areas in addition to the preventive chemotherapy.

Moreover, any interventional program should better consider all age groups of the community for complete curative and preventive management of intestinal schistosomiasis.

Data availability

The datasets used and analyzed in the study are available from the corresponding author upon reasonable request.

Received: 20 July 2024; Accepted: 30 December 2024
Published online: 16 January 2025

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Acknowledgements

It is with great pleasure that we thank Mattu University's Office of the Research Affairs Directorate for their technical support of this project. Data collectors and study participants also owed a debt of gratitude for their participation in the study. School directors and teachers should be thanked delightedly for their priceless collaboration.

Author contributions

Conceptualization, Y.N., T.B., and S.T.; Data curation, T.D., A.M., and A.G.; Formal analysis, T.D., A.M., A.G., and W.G.; Funding acquisition, O.G.; Investigation, O.G.; Methodology, B.E., T.S.; Re-sources, G.T; Supervision, D.O., and M.B.; Writing – original draft, Y.N., and T.B.; Writing – re-view & editing, Y.N., T.B., E.C., and D.G.

Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

Mattu University's College of Health Sciences Institutional Review Board granted the study approval and ethical clearance with a Ref. No: CHS/157/23. The study protocol was conducted according to the Declaration of Helsinki. Study participants and school teachers were provided with overviews of the study. Then, for children below 16 years old, informed consent was taken from their legal guardian before assent was taken directly from the child. On the other hand informed consent was taken directly from all children above 16 years regarding sociodemographic and clinical data collection. The positive cases are then linked to the nearest health facilities for appropriate drug administration and better treatment.

Additional information

Correspondence and requests for materials should be addressed to Y.N.