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# *Schistosoma mansoni* infection and risk factors among the fishermen of Lake Hawassa, southern Ethiopia

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## Abstract

Schistosomiasis is a neglected tropical parasitic disease caused by different species of genus *Schistosoma*. *Schistosoma mansoni* causes a severe intestinal parasitic infection of high public and medical importance in Ethiopia. This study aimed to determine the prevalence of, and risk factors for, *S. mansoni* infection among the fishermen of Lake Hawassa, southern Ethiopia, using a cross-sectional study design. A total of 243 fishermen were selected from the Hawassa Town Fishermen Association's list in 2013. Data on socio-demographic characteristics and risk factors were collected from the fishermen using semi-structured questionnaires. Stool samples were collected and processed using the Kato–Katz thick smear technique. The overall prevalence of *S. mansoni* among the fishermen was 29.21% and the mean intensity of infection was 158.88 eggs per gram (EPG). The overall prevalence of intestinal helminths, including *S. mansoni*, was 69.54%. Similar prevalences of *S. mansoni* were recorded in age groups 15–19, 20–24 and 25–29 years: 31.82%, 31.75% and 31.94%, respectively. Fishermen who swam a minimum of once a week in Lake Hawassa were 2.92 times (95% CI: 1.554, 5.502) more likely to have acquired *S. mansoni* infection than those who swam in the lake less than once a week. The results indicate moderate endemicity of *S. mansoni* infection among the fishermen of Lake Hawassa. These fishermen could be a potentially high-risk group for *S. mansoni* infection and might be responsible for the transmission of infection to other segments of the community visiting the lake for recreation. Moreover, a high prevalence of soil-transmitted helminths (STHs) was recorded among the fishermen. Integrated prevention and control strategies for schistosomiasis and STHs by different sectors are needed to tackle this problem.

**Keywords:** *S. mansoni*; Fishermen, Lake Hawassa

## Introduction

Schistosomiasis is a chronic parasitic disease caused by trematodes of the genus *Schistosoma*. *Schistosoma mansoni* and *S. haematobium* are the major causes of human schistosomiasis in Ethiopia (Kloos *et al.*, 1988). *Schistosoma mansoni* and soil-transmitted helminths (STHs) are major causes of intestinal helminthiasis in developing countries and their impact on public health has been underestimated due to the chronic nature of the disease and low mortality rate (Thiongo *et al.*, 2001). The distribution and prevalence of various species of intestinal helminths, including *S. mansoni*, differ from region to region due to environmental, social and geographical factors (Legesse & Erko, 2004). In general, the burden of intestinal helminthiasis is high throughout the tropics, especially among poor communities, and increasing trends in the infections have been recorded in developing nations, including Ethiopia (Tadesse, 2005).

The global burden of schistosomiasis indicates about 200–209 million infected individuals and 600–779 million people at risk of infection (Chitsulo *et al.*, 2000). The estimated total number of

people requiring treatment for schistosomiasis in 2014 was 258,875,452. About 91.4% of these were living in the African region (WHO, 2016). In Ethiopia, about 5.01 million people are thought to be infected with schistosomiasis and 37.5 million to be at risk of infections (Steinmann *et al.*, 2006).

Despite the low mortality resulting from *S. mansoni* infection, the chronic nature of the disease and the associated morbidity has an impact among fishermen, farmers and labourers, who have frequent contact with water sources contaminated with *S. mansoni* cercariae (Erko, 2009). Among the different risk factors for *S. mansoni* endemicity, water conservation, irrigation and hydroelectric power projects have contributed a lot to the spread of the disease and changed its epidemiology (Essa *et al.*, 2012). In particular, fishing, bathing, washing clothes and other activities involving frequent water contact could increase the transmission of *S. mansoni* (Cheesbrough, 2006).

The life cycle of *S. mansoni* involves an adult dioecious sexual stage with the definitive human host and an asexual reproductive stage within an intermediate host snail. When the parasite eggs reach fresh water they hatch and free-swimming miracidial forms are released. These penetrate the bodies of suitable aquatic snails and for the next 3–5 weeks multiply asexually to form hundreds of fork-tailed cercariae. The cercariae leave the snail and swim to a human where they penetrate the skin. Inside the human body the schistosomula are transported through the blood or lymphatic system to the right side of the heart, then to the lung, where they mature for a period of 7–10 days. They then break into pulmonary veins and travel through the systemic circulation to reach the portal circulation and the liver, where they develop into adult worms. The time between first skin penetration by a cercaria to first ovum production by the adult worm is around 4–6 weeks (Satoskar, 2009).

Control of schistosomiasis has proven difficult because of rapid re-infection due to limited means of control for the intermediate host snail and lack of sanitary facilities in most endemic areas (Rollinson *et al.*, 2013; Grimes *et al.*, 2014). A variety of approaches, including Water, Sanitation and Hygiene (WASH) initiatives, Information, Education and Communication (IEC) campaigns, behavioural change and snail control have been employed, but preventive chemotherapy with praziquantel has been the fundamental approach since the early 1980s. There is currently no other remedy to put in its place and the next generation of anthelmintic drugs is yet to appear. Since the last surge of drug discovery for parasitic worm diseases in the 1970s, resulting in the marketing of praziquantel and ivermectin which, together, cure several of the major helminth infections (Keiser & Utzinger, 2010), no new drugs for helminthiasis have been approved. It is even more worrisome that the drug discovery and development pipeline for neglected tropical diseases has run dry over the past 40 years (Pedrique *et al.*, 2013).

Socially, Lake Hawassa fishermen are very isolated from their wider communities and may miss routine prevention and control activities. Moreover, due to the lack of environmental sanitation and latrine facilities, they may defecate in open fields around the shore of the lake. Therefore, assessing the epidemiology of these helminths among the fishermen may contribute to the success of current control and elimination strategies.

From the authors' observation, there are thousands of people around Lake Hawassa who are engaged in fishing and fish processing. The majority of fishermen routinely swim, bathe and wash clothes in the lake. These activities can easily expose them to *S. mansoni* and other water-borne parasitic infections. Although different epidemiological studies of schistosomiasis have been undertaken among school children in Ethiopia, the magnitude of *S. mansoni* among these fishermen has not been adequately assessed. The current study was undertaken to determine the prevalence of *S. mansoni* and its risk factors among the fishermen of Lake Hawassa. The findings may inform the scaling-up of control and elimination measures of *S. mansoni* in the study area and in the country at large.

## Methods

### Study area and population

Hawassa Town is located in the southern part of Ethiopia 250 km from Addis Ababa, the capital city. Hawassa is the capital of the Southern Nation and Nationalities People Region (SNNPR). It has a hot climate and is at an altitude of 1680 m above sea level. The city is surrounded by Lake Hawassa, which forms part of the East African Rift Valley belt. The lake is 16 km long and 9 km wide, with a surface area of 129 km<sup>2</sup> and a maximum depth of 10 m. It has an elevation of 1708 m.

The source population of the study were people living around Lake Hawassa. Study participants were selected from the Fishermen Association list. Fishermen who had been engaged in fishing for a minimum of 3 months were included in the study; those who had taken any anti-schistosomal or antihelminthic treatment within the past 3 months were excluded from the study.

### Study design and sample

The study was cross-sectional in design. The sample size was calculated using the 95% confidence interval with 5% marginal error using the formula:

$$n = \frac{z^2 p(1-p)}{d^2},$$

where  $n$  is the sample size,  $z$  is  $z$  statistic for a level of confidence ( $z = 1.96$  at 95% CI),  $p$  is the prevalence ( $p = 0.50$ ),  $d$  is the precision (if 5%,  $d = 0.05$ ). The calculated sample size was 384. Since the total number of people in the Fishermen Association was less than 10,000, a population correction formula was used:

$$n_o = \frac{n}{1 + \frac{n}{N}},$$

where  $n$  is the sample size from the finite population,  $N$  is the total study population size and  $n_o$  is the corrected sample size. Then:  $n_o = \frac{384}{1 + \frac{384}{520}} = 221$ . Including 10% for non-response rate, the final sample size became 243.

Using the systematic sampling technique, study participants were selected from the sample frame of the list of fishermen in the Fishermen Association registration book. The following steps were followed. The sample interval size,  $k$ , was calculated as:  $k = N/n = 520/243 = 2.13 \sim 2$ . After the random selection of the 1<sup>st</sup> participant, every 2<sup>nd</sup> person in the fishermen list was included until 243 fishermen had been selected.

### Data collection

A semi-structured questionnaire was used to collect socio-demographic data and risk factors by trained data collectors (who were qualified in research data collection) and who had much experience in data collection in different health research surveys. The participants were oriented on how to provide a sufficient stool specimen by the principal investigator and data collectors. A fresh faecal specimen was collected in labelled, clean, dry, leak-proof containers. The stool specimen was processed using the Kato–Katz thick smear technique by an experienced laboratory technologist who was qualified in the Kato–Katz technique. Each smear was read within 30–40 minutes for the detection and identification of hookworms and re-read after 24 hours for *S. mansoni*. The number of eggs of each species was recorded and converted into the stool EPG in order to analyse the intensity of infection. The EPG is calculated in Kato–Katz by multiplying the egg count by a conversion factor of 24 (Engbaek *et al.*, 2003).

Intensity of infection was graded as light, moderate and heavy by counting the helminths eggs in the faeces. The intensity of *S. mansoni* infection was considered as: light: 1–99 EPG; moderate: 100–399 EPG; and heavy:  $\geq 400$  EPG. The intensity for *T. trichiura* was considered as light: 1–999

EPG; moderate: 1000–9999 EPG; heavy:  $\geq 10,000$  EPG. The intensity for *A. lumbricoides* was considered as: light: 1–4999 EPG, moderate: 5000–49,999 EPG, heavy:  $\geq 50,000$  EPG; and the intensity for hookworm was considered as light: 1–1999 EPG; moderate: 2000–3999 EPG; and heavy:  $> 3999$  EPG (Montresor *et al.*, 1998).

Standard operating procedures were followed during stool specimen collection, transport processing, examination and results recording. From all positive and negative Kato–Katz thick smears, 10% were randomly selected and read by an experienced laboratory technologist who was blind to the primary result and agreement was made for discrepancies by allowing the third laboratory technologists to examine the slide.

After explaining the objective and the purpose of the study, written informed consent was obtained from each fishermen involved in the study. Confidentiality of the information was assured and privacy of the respondent was maintained. The participants' results were kept confidential and fishermen infected with *S. mansoni* and other intestinal helminths were treated with praziquantel (40 mg/kg body weight) and albendazole (400 mg), according to WHO guidelines, by experienced health professionals.

### Data analysis

All questionnaires for socio-demographic and risk factors were checked for completeness. The data were coded, entered, cleaned and analysed using SPSS version 16.0 statistical packages. Those variables with significant association in bivariate analysis were fitted to multivariate analysis to determine the independent predictors, and statistical significance was considered at  $p < 0.05$ .

### Results

The 243 participating fishermen ranged in age from 15 to 39 years. All were registered in the Lake Hawassa Fishermen Association list; no one can fish regularly without registering on this list. All registered fishermen were male. The majority of the 243 participants were in the 25–29 year age group. About 73% (178/243) had an elementary level of education. About 58% (142/243) were from urban areas and 42% (101/243) were from rural areas (Table 1).

### Prevalence of intestinal helminthic infections

The prevalence of *S. mansoni* among the fishermen was 29.22% (71/243). Prevalences of 31.82% (14/44), 31.75% (20/63), 31.94% (23/72), 17.07% (7/41) and 30.43% (7/23) were recorded for the age groups 15–19, 20–24, 25–29, 30–34 and 35–39 years, respectively. Of the total 243 stool samples examined, 169 were positive for one or more intestinal helminth, giving an overall prevalence of intestinal helminth infections of 69.54%. The prevalences of *A. lumbricoides*, *T. trichiura* and hookworm species were 40.74% (99/243), 35.80% (87/243) and 5.76% (14/243), respectively (Fig. 1).

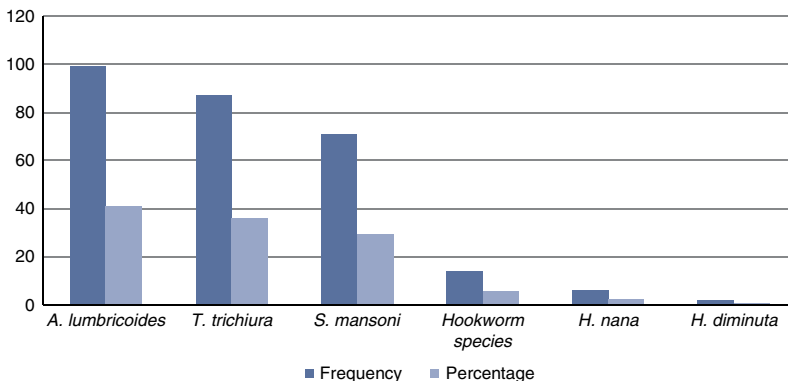
Of the 169 helminth-infected fishermen, 43.78% (74/169) had a single helminth infection, while 56.21% (95/169) were infected with more than one intestinal helminth. The most common multiple helminth infection was a double infection of *A. lumbricoides* and *T. trichiura* (50.52%), followed by *S. mansoni* and *T. trichiura* (13.68%). The major triple infection (9.47%) was *S. mansoni*, *A. lumbricoides* and hookworm species.

### Intensity of intestinal helminth infections

The mean intensity of *S. mansoni* infection for the participants was 158.88 EPG. The levels of infection intensities for *S. mansoni* were 52.11%, 43.66% and 4.23% for light, moderate and heavy infection intensities, respectively. The mean infection intensities of *A. lumbricoides*, *T. trichiura* and hookworm were 1349.04 EPG, 246.24 EPG and 99.36 EPG, respectively. A light intensity of

**Table 1.** Socio-demographic characteristics of the fishermen of Lake Hawassa, southern Ethiopia, 2013 (N = 243)

Characteristic		n	%
Age group (years)	15–19	44	18.10
	20–24	63	25.93
	25–29	72	29.63
	30–34	41	16.87
	35–39	23	9.47
Religion	Christian	169	69.55
	Muslim	74	30.45
Level of education	Read and write only	32	13.17
	Grade 1–8	178	73.25
	Grade 9–12	27	11.11
	Grade >12	6	2.47
Residence	Urban	142	58.44
	Rural	101	41.56
Monthly income	Birr <500	56	23.04
	Birr 500–1500	177	72.84
	Birr >1500	10	4.12

**Figure 1.** Prevalence and species distribution of intestinal helminths among the fishermen of Lake Hawassa, southern Ethiopia, 2013.

*A. lumbricoides* and *T. trichiura* infection was recorded in 81.82% and 91.95% of the fishermen, respectively. Only light infection intensity was recorded in hookworm-infected fishermen (Table 2).

### **Risk factors for *S. mansoni* infection**

The factors associated with *S. mansoni* infection among the fishermen were assessed using bivariate and multivariate logistic regression analysis (Table 3). The incidence of *S. mansoni*

**Table 2.** Intensity of *S. mansoni*, *A. lumbricoides*, *T. trichiura* and hookworm infections in the fishermen of Lake Hawassa, southern Ethiopia, 2013 (N=243)

Intensity of infection (EPG)	<i>n</i>	%
<i>S. mansoni</i>		
Light (1–99)	37	52.11
Moderate (100–399)	31	43.66
Heavy ( $\geq 400$ )	3	4.23
<i>A. lumbricoides</i>		
Light (1–4999)	81	81.82
Moderate (5000–49,999)	18	18.18
<i>T. trichiura</i>		
Light (1–999)	80	91.95
Moderate (1000–9999)	7	8.05
Hookworm species		
Light (1–1999)	14	100

infection among the fishermen was found to be significantly associated with swimming, bathing and other activities involving frequent water contact in Lake Hawassa. On the other hand, there was no statistically significant association between *S. mansoni* infection and the water sources used for drinking by fishermen. Swimming habit, frequency of swimming and frequency of lake water contact were found to be independent predictors for *S. mansoni* infection among the fishermen. Fishermen who swam a minimum of once a week in Lake Hawassa were 2.92 times (95% CI: 1.554, 5.502) more likely to acquire *S. mansoni* infection than who swam in the lake less than once a week. However, frequency of other water contact and a habit of swimming in other water bodies were not found to be risk factors for infection, even if they had an association in the bivariate analysis. No statistically significant association was found between *S. mansoni* infection and the place where the fishermen bathed.

## Discussion

Schistosomiasis is a neglected tropical parasitic diseases with multiple risk factors related to the parasite responsible, *S. mansoni*, and its hosts (humans and snails) and the environment in which they live (Elbaz & Esmat, 2013). Due to the nature of their occupation, fishermen can easily be infected with *S. mansoni* and might be responsible for transmission of the disease to other segments of the population.

The study found the overall prevalence of *S. mansoni* among the fishermen of Lake Hawassa to be 29.22% in 2013. Tukahebwa *et al.* (2013) found the prevalence among fishermen in East Africa to be higher, at 88.6%. Similarly, other researchers found high infection levels in other African countries: 72% (Kabatereinea *et al.*, 2004) and 47.4% (Odongo *et al.*, 2011) in Uganda; 47.85% in Tanzania (Mazigo *et al.*, 2014); 72.4% in Egypt (El-Hawey *et al.*, 1995) and 41.3% in Ethiopia (Merid *et al.*, 2001). The difference in prevalence might be due to variations in geography, climate and ecology, study design, and the awareness level and immune status of the fishermen. Moreover, Uganda and Tanzania are among the world's top fishing nations and larger segments of the population are engaged in fishing than in Ethiopia. Similarly, a higher prevalence of *S. mansoni* (33%) has been reported in the same study area (Lake Hawassa, Ethiopia) among

**Table 3.** Bivariate and multivariate logistic regression analysis of factors associated with *S. mansoni* infection among the fishermen of Lake Hawassa, southern Ethiopia, 2013 (N=243)

Factor	<i>S. mansoni</i> infection status			COR <sup>a</sup> [95%CI]	p-value	AOR <sup>b</sup> [95%CI]	p-value
	Positive n (%)	Negative n (%)	Total n (%)				
Swimming in lake							
Yes	63 (27.27)	168 (72.73)	231 (95.06)	0.188 [0.055, 0.644]	0.008	0.203 [0.052, 0.796]	0.022
No	8 (66.67)	4 (33.33)	12 (4.94)	1			
Frequency of swimming in lake							
Always <sup>c</sup>	43 (37.72)	71 (62.28)	114 (46.91)	2.185 [1.242, 3.842]	0.007	2.924 [1.554, 5.502]	0.001
Sometimes <sup>d</sup>	28 (21.71)	101 (78.29)	129 (53.09)	1			
Bathing place							
River	11 (61.11)	7 (38.89)	18 (7.41)	0.3143 [1.013, 9.752]	0.047	2.046 [0.590, 7.101]	0.259
Lake	45 (25.00)	135 (75.00)	180 (74.07)	0.667 [0.329, 1.350]	0.260	0.611 [0.288, 1.295]	0.198
At home	15 (33.33)	30 (66.67)	45 (18.52)	1			
Frequency of lake water contact							
Daily	57 (26.03)	162 (73.97)	219 (90.12)	0.251 [0.106, 0.597]	0.002	0.203 [0.078, 0.529]	0.001
Sometimes	14 (58.33)	10 (41.67)	24 (9.88)	1	0.946		
Drinking water source							
Pipe	51 (28.81)	126 (71.19)	177 (72.84)	1			
River	17 (30.91)	38 (69.09)	55 (22.63)	1.105 [0.572, 2.134]	0.766		
Lake	3 (27.27)	8 (72.73)	11 (4.53)	0.926 [0.236, 3.632]	0.931		

<sup>a</sup>COR: Crude Odds Ratio.<sup>b</sup>AOR: Adjusted Odds Ratio.<sup>c</sup>Always: swam a minimum of once a week.<sup>d</sup>Sometimes: swam less than once a week.

children engaged in fishing and fish-processing activities (Merid *et al.*, 2001). The variation of prevalence might be due to the frequent water contact of the children in Lake Hawassa.

The *S. mansoni* prevalence reported here is higher than that reported in fishermen from Burkina Faso (16.35%; Zongo *et al.*, 2008) and Egypt (26.6%; Taman *et al.*, 2014). Similarly, a lower prevalence (12.5% vs 26.3%) of *S. mansoni* has been reported among subsistence fishermen and commercial fishermen in Zambia (Chimbari *et al.*, 2003). The difference in prevalence might be due to geographic, climatic and ecological factors, too. Moreover, personal and environmental sanitation levels might be responsible for the difference of *S. mansoni* prevalence from place to place.

According to the literature, there is high chance of co-endemicity for schistosomiasis and STHs in areas where schistosomiasis is prevalent (Yajima *et al.*, 2011). Even though it was not the primary objective of this study, the prevalence of other intestinal helminths was also assessed. The overall prevalence of intestinal helminths, including *S. mansoni*, among the fishermen was



high (69.55%). Of these, STHs were found to be the major helminths in the study fishermen. There was a higher prevalence of *A. lumbricoides*, followed by *T. trichiura* and hookworms. The prevalence of *A. lumbricoides* was comparable to that found among fishermen in Vietnam, but higher prevalences of *T. trichiura* and hookworm have been reported in Vietnam (Olsen *et al.*, 2006). Similarly, a higher prevalence of all three STHs has been reported among children in fishing villages in India (Naish *et al.*, 2004). The difference in prevalence might be due to geographic, climatic and socioeconomic statuses, environmental factors and the personal hygiene levels of the study participants. However, the prevalence of the three STHs in the present study area was higher than that reported among community members mainly engaged in fishing in the rural area of Abaya Deneba adjacent to Lake Ziway, Ethiopia (Nyantekyi *et al.*, 2014). Apart from climatic and geographic factors, the variation of prevalence might be due to the difference in the diagnostic methods employed to assess STHs. The majority of infection intensities were light among the fishermen in the study area and this is comparable to findings in Egypt (Taman *et al.*, 2014).

The transmission of *S. mansoni* is influenced by broader social determinants. The disease patterns show geographical variations, with interactions between biological, social, behavioural and environmental factors (Grimes *et al.*, 2015). This study found that infection among fishermen was significantly associated with water contact behaviour. Specifically, swimming habit, frequency of swimming and frequent contact with lake water were found to be independent predictors of *S. mansoni* infection among the fishermen in the study. It would be very difficult for fishermen to avoid such water contact behaviours as their livelihood depends on fishing. Changing fishing livelihoods, attitudes to public health interventions, access to water and sanitation facilities, hygiene practices and the use preventive chemotherapy could help to reduce the burden of *S. mansoni* in fishing communities.

In conclusion, the results of this study provide evidence of moderate endemicity of *S. mansoni* among the fishermen of Lake Hawassa, southern Ethiopia. Fishermen could be a potential risk group for *S. mansoni* infection and might be responsible for the transmission of infection to other segments of the community who have contact with lake water. Unexpectedly, a high prevalence of STHs was also recorded among the fishermen. Therefore, integrated prevention and control strategies for both STHs and schistosomiasis from different sectors and using multiple prevention and control strategies will be important to tackle the problem.

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**Conflicts of Interest.** The authors declare that they have no conflict of interest associated with the publication of this manuscript.

**Ethical Approval.** Ethical clearance was obtained from the Institutional Review Board (IRB) of the Institute of health, Jimma University, Ethiopia.

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