

Community Seroprevalence of Anti-Schistosoma mansoni IgG Antibodies and Associated Factors in Baddan District, Ibb Governorate, Yemen

Lina Mohammed Alareqi

Ibb University

Hind Fadl Basha

Ibb University

Awsan Rashad Basha

Ibb University

Alariqi Reem

Al-Razi University

Wadee Abdullah Al-Shehari

Dr. wadee40@yahoo.com

Ibb University

Article

Keywords: Schistosomiasis, S. mansoni, Seroprevalence, Risk factors, Yemen

Posted Date: October 19th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10536400/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Schistosomiasis is an important neglected tropical disease in Yemen and is endemic especially in rural areas where socioeconomic and environmental factors facilitate ongoing transmission. This study was conducted to determine the seroprevalence of anti-Schistosoma mansoni IgG antibodies and associated risk factors in Al-Sanahi area, Baddan District, Ibb Governorate, Yemen.

Methods

A community based cross sectional study was conducted in the community. Serum samples from 90 subjects were tested for anti- *Schistosoma mansoni* (*S. mansoni*) IgG antibodies by enzyme-linked immunosorbent assay (ELISA). A systematic questionnaire was used to collect behavioral and demographic data. Logistic regression analysis was conducted to determine the variables associated with seropositivity.

Results

Anti-*S. mansoni* IgG seroprevalence was 41.1% (37/90; 95% CI: 31.5%–51.4%). The significant predictors of anti-*S. mansoni* IgG seropositivity were swimming (AOR = 12.727, 95% CI: 2.069–78.279; $P = 0.006$), not wearing shoes during water contact (AOR = 10.904, 95% CI: 2.189–54.320; $P = 0.004$), defecating near water sources (AOR = 20.037, 95% CI: 2.465–162.874; $P = 0.005$), absence of household sanitation (AOR = 17.169, 95% CI: 5.672–51.968; $P = 0.005$) and presence of blood in stool (AOR = 32.180, 95% CI: 3.191–327.794; $P = 0.002$) on multivariable logistic regression.

Conclusion

The study shows evidence of a high level of serological exposure to *S. mansoni* among residents of Al-Sanahi, Baddan District. These data indicate the need for further epidemiological studies including parasitological and molecular studies to confirm the presence and level of active transmission in the community.

Introduction

Schistosomiasis is one of the most important neglected tropical diseases (NTDs) and remains a major public health problem in many low- and middle-income countries. It is strongly associated with poverty, poor sanitation, lack of access to clean water and repeated human contact with polluted waters. It is caused by blood flukes of the genus *Schistosoma*. According to the World Health Organization (WHO), more than 250 million people require preventive chemotherapy annually, the majority of whom live in

sub-Saharan Africa. Nevertheless, transmission persists in parts of the Middle East, South America and Asia ^(1,2).

Although schistosomiasis is under control in many countries, it remains endemic in several Middle Eastern countries, including Yemen. Due to ongoing conflict, poor water and sanitation infrastructure, unreliable health services and suitable environmental conditions, Yemen has one of the highest rates of schistosomiasis in the region. However, the national schistosomiasis control program has registered considerable decreases in disease prevalence with the delivery of preventive chemotherapy and integrated control interventions, since its launch in 2009 with technical and financial support from the World Bank and WHO, transmission continues in a number of endemic governorates, especially in rural areas where contact with contaminated water is frequent ^(3–5).

Human infection occurs when cercariae released from infected freshwater snails penetrate the skin during contact with contaminated water ^(6,7). The infection can progress from acute schistosomiasis (Katayama syndrome) and cercarial dermatitis to a chronic illness that affects the intestines, liver, urinary tract, and other organs, causing significant morbidity^(7,8,9), particularly in school-age children and economically disadvantaged populations ^(10,11).

In December 2009, Yemen, with financial support from the World Bank and WHO, embarked on a six-year project to eliminate *schistosomiasis* related morbidity and control intestinal worms across Yemen ⁽⁴⁾. Despite the intensive control efforts by the government and international bodies, *schistosomiasis* is still a life-threatening public health problem in Yemen with an estimated 3 million cases ^(11,12). In addition, a survey was conducted in Ibb Governorate.

The aim was to determine the prevalence and focal distribution of *Schistosoma* infection and intestinal parasites to provide a reference for assessing the need for community intervention. A total of 230 children (5–18 years) from 7 villages in the Assahul Valley of Ibb Governorate in Yemen were included. The rate of *Schistosoma* infection was 37% (35% *S. mansoni* and 2% *S. haematobium*). Living close to the valley, being male and frequent water contact activities were significantly associated with *Schistosoma* infections ⁽¹³⁾.

In Yemen, there are still significant epidemiological gaps despite continuous efforts to control *schistosomiasis*. Community-based Sero epidemiological data from different endemic rural areas are lacking and most of the existing research has been done on students or particular high-risk groups. Little is known about the behavioral, social and demographic characteristics associated with exposure to *S. mansoni* infection in these populations. The absence of recent local evidence may limit the application of tailored prevention and control approaches.

The agricultural activities, constant human contact with freshwater, and limited sanitary facilities in the Al-Sanahi area of Baddan District, Ibb Governorate, make the area relevant for studying *schistosomiasis* transmission. However, limited recent data on *S. mansoni* exposure are available in this community. The

generation of local epidemiological evidence may contribute to broader *schistosomiasis* control efforts, and help inform prevention and control activities in the study area. Thus, the present study aimed to determine the seroprevalence of anti-*S. mansoni* IgG antibodies in Al-Sanahi area, Baddan District, Ibb Governorate, Yemen, and to identify associated demographic, socioeconomic and behavioral factors.

Methods

Study Design and Duration

A community-based cross-sectional study was carried out in Al-Sanahi village, Baddan District, Ibb governorate, Yemen. Participants were recruited from households in the study area by using a convenience sampling approach. Household visits were conducted over 2 days during the study period, and eligible residents present at the time of the visit were invited to participate. Detailed information about the study objectives and procedures was provided to potential participants, and those who met the pre-defined inclusion criteria and agreed to participate voluntarily were enrolled after giving written informed consent. More than one eligible person per household was allowed to participate. Participation was voluntary and those unwilling to participate were not recruited.

Study Setting

The study was performed in Al-Sanahi Area, Baddan District, Ibb Governorate, approximately 193 km south of the capital of Yemen, Sana'a (Fig. 1). The region experiences a highland climate with an average annual temperature of approximately 18°C and an economy that is mainly dependent on agriculture. Seasonal streams, irrigation canals, and frequent human contact with fresh water provide favorable conditions for the transmission of *schistosomiasis*.

Inclusion and Exclusion Criteria

The study population consisted of permanent residents of Al-Sanahi Area aged one year and above who had lived in the area for at least six months and agreed to participate. Written informed consent was obtained from all adult participants and from the parents or legal guardians of children. The exclusion criteria were persons who refused to participate, persons who were very ill at the time of data collection or persons who provided inadequate blood samples for serological testing.

Data Collection

Data were collected using a structured questionnaire, developed from a review of previous epidemiological studies on *schistosomiasis*, via face-to-face interviews. The questionnaire collected demographic and socioeconomic characteristics, environmental and behavioral risk factors, water-contact activities, sanitation and hygiene practices, knowledge of *schistosomiasis* and selected clinical symptoms.

Sample Size and Sampling

The minimum sample size was calculated by Epi Info™ version 7.1.3, using an expected prevalence of 9.1% according to a previous study in Ibb Governorate, Yemen ⁽¹⁴⁾. The sample size was initially estimated based on an expected prevalence of 9.1%, a 95% confidence level, a 5% margin of error, and a design effect of 1.0. A total of 90 eligible participants were ultimately recruited during the study period using convenience sampling. Participants were recruited from eligible volunteers who were available during the study period and met the predefined inclusion criteria. Written informed consent was obtained from all participants before enrollment, and participation was entirely voluntary.

Sample Collection

Venous blood was collected from each participant into approximately 2 mL sterile vacuum blood collection tubes without anticoagulant and was transferred aseptically. The site of venipuncture was disinfected with 70% ethanol and allowed to air dry before venipuncture. Blood was allowed to clot for 20–30 minutes at room temperature, then centrifuged at 3000 rpm for 10 minutes to separate the serum. The separated serum was dispensed in appropriately labeled sterile microtubes and stored at 2–8°C until serological analysis.

Serological Analysis

Serum samples were tested for the presence of anti-*S. mansoni* IgG antibodies using the RD-Ratio Diagnostics E-SCG-K48 Schistosoma IgG ELISA kit (Ratio Diagnostics GmbH, Germany). The assay was performed as per the manufacturer's protocol. Optical density values were determined using an ELISA microplate reader and the test results were interpreted according to the cut-off values recommended by the manufacturer. Samples were classified as positive and negative for anti-*S. mansoni* IgG antibodies using these criteria.

Statistical Analysis

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS, version 25, IBM Corp., Armonk, NY, USA). Descriptive data from the surveys and laboratory tests were shown with percentages and frequencies. The correlations and differences among categorical variables were analyzed using the Pearson chi-square test. The bivariate analysis was presented with 95% CIs and adjusted odds ratios (ORs). Statistical significance was defined as $P\text{-value} < 0.05$. Variables with a $P\text{-value}$ of ≤ 0.05 in the bivariate logistic regression analysis were used to calculate the adjusted odds ratios (AORs) and to determine the independent predictors of infection. A $P\text{-value}$ of < 0.05 was taken as statistical significance.

Results

The Sociodemographic Characteristics of the Study Participants

The present study was carried out in the Al-Sanahi area of the Baddan District of the Ibb Governorate of Yemen, where 90 samples were tested. The table indicates that 67 (74.4%) of the participants were men whereas only 23 (25.6%) were women. The study included 68 participants (75.6%) aged 1–18 and only 22 participants (24.4%) older than 18. About 73 (81.1%) persons were single and 17 (18.9%) persons were married. The investigation also discovered that 36 people (40%) had a monthly salary above 50,000 YR, and 54 people (60%) earned less than 50,000 YR. Father According to the data 70 people (77.8%) were educated and 20 people (22.2%) were illiterate. Besides, 47(52.2%) of the participants had educated mothers and 43(47.8%) had illiterate mothers (Table 1).

Table 1: The sociodemographic, socioeconomic and behavioral characteristics of the study population in Al-Sanahi area, Baddan district, Ibb governorate, Yemen (n=90)

Variable	Characteristics	N	Percent%
Gender	Male	67	74.4%
	Female	23	25.6%
Age	1-18 years	68	75.6%
	> 18 years	22	24.4%
Marital status	Single	73	81.1%
	Married	17	18.9%
Family Size	≤10	79	87.8%
	>10	11	12.2%
Household monthly income	≤50.000YR	53	58.9%
	> 50.000YR	37	41.1%
Father's education levels	Educated (at least primary education)	69	76.7%
	Illiterate	21	23.3%
Mother's education levels	Educated (at least primary education)	47	52.2%
	Illiterate	43	47,8%
Father's occupational status	Employee	60	66.7%
	Unemployed	30	33.3%

Seroprevalence of ***Schistosoma mansoni*** and its associated risk factors

A total of 90 specimens were analyzed for the detection of IgG anti-*Schistosoma mansoni*, indicating chronic infection by ELISA method. Overall prevalence of *S. mansoni* antibodies was 41.1% The

percentage of seropositive females was 34.8% and males 43.3%, indicating a higher seroprevalence of anti-*S. mansoni* IgG antibodies in male participants.

Factors associated with *Schistosoma mansoni* Seropositivity among community participants in Al-Sanahi Area, Baddan District, Ibb Governorate, Yemen (n = 90)

Table 2: Univariate and multivariable logistic regression analysis of factors associated with anti-*S. mansoni* IgG seropositivity among 90 community participants from Al-Sanahi area, Baddan district, Ibb Governorate, Yemen. The results show that age was significantly associated with anti-*S. mansoni* IgG seropositivity. The seropositivity rate was higher in 1–18 years participants (32/68, 47.1%) than those >18 years (5/22, 22.7%) and the difference was not statistically significant ($P=0.066$). Similarly, the gender was not significantly associated with seropositivity ($P=0.452$) Likewise, no statistically significant association was observed between father's education ($P=0.490$) and father's employment status ($P=0.545$) with anti-*S. mansoni* IgG seropositivity. Mother's education remained a significant protective factor in the multivariable logistic regression analysis. The study found that participants whose mothers had formal education were significantly less likely to be seropositive for anti-*S. mansoni* IgG antibodies compared to those whose mothers were illiterate (27.7% vs 55.8%; $P=0.002$). Furthermore, participants from households with a monthly income of $\leq 50,000$ YR had a lower seropositivity rate than those from households with higher incomes (32.1% vs. 54.1%). Monthly household income remained independently associated with anti-*S. mansoni* IgG seropositivity in the multivariable logistic regression analysis (AOR=3.774, 95% CI: 1.393-10.223; $P=0.009$). In contrast, family size was not significantly associated with seropositivity ($P=0.796$).

The seropositivity rate for anti-*S. mansoni* IgG antibodies was lower among participants who were aware of schistosomiasis than among those who were not (34.4% vs. 44.8%); however, this association was not statistically significant ($P=0.336$). Likewise, participants who used a towel after swimming had a lower seropositivity rate than those who did not (20.0%, 11/55 vs. 74.3%, 26/35, $P=102$). Participants who helped their fathers with farming activities had a higher seropositivity rate than those who did not (14/27, 51.9% vs. 23/63, 36.5%); however, this difference was not statistically significant ($P=0.151$). Data suggest that behavioral practices and environmental variables were the major factors associated with anti-*S. mansoni* IgG seropositivity in this group. Participants reporting swimming had a significantly higher rate of seropositivity compared to those who did not (59.3% vs. 13.9%; AOR=7.398, 95% CI:1.180-46.37; $P=0.033$). Similarly, participants who did not wear shoes during water contact had higher seropositivity rate than those who wore shoes (8/50, 16.0% vs.29/40, 72.5%; AOR= 4.408, 95% CI: 0.711-27.325; $P=0.111$).The hygiene after water exposure also played a major role. The data showed that not using a towel after swimming is a major risk factor. Environmental sanitation continues to be a key factor in the transmission of the disease; the presence of poor sanitation facilities in the home and open defecation in proximity to water sources were both extremely highly correlated with infection rates. Furthermore, blood in the stool and a history of schistosomiasis were found to be significant predictors of anti-*S. mansoni* IgG seropositivity ($P=0.002$ and $P=0.018$, respectively). Overall, these results imply that frequent water contact, high-risk behavioral habits, and poor sanitation are substantially linked to anti-*S.*

mansoni IgG seropositivity in this population. Furthermore, there was a high variation in anti-S. *mansoni* IgG seropositivity between those with and without access to household sanitation (70.5% vs. 13.0%; AOR= 14.824, 95% CI: 2.070–106.16; $P=0.007$). On the other hand, anti-S. *mansoni* IgG seropositivity was not significantly associated with source of domestic water, washing clothing or utensils in open water, or family history of schistosomiasis ($P=0.450$, $P=0.205$ and $P=0.137$ respectively).

Table 2: Factors associated with *Schistosoma mansoni* infection among community in Al-Sanahi area, Baddan district, Ibb governorate, Yemen (n=90).

Variables	N	Infection by <i>S. mansoni</i>			
		n (%)	OR (95% CI)	AOR (95% CI)	<i>P</i> value
Age					
1-18 years	68	32(47.1)	Reference		
> 18 years	22	5 (22.7)	0.331(0.110-0.999)	0.348(0.113-1.074)	0.066
Gender					
Male	67	29(43.3)	Reference		
Female	23	8 (34.8)	0.699(0.261-1.871)	0.675(0.242-1.881)	0.452
Family Size					
≤10	79	32(40.5)	Reference		
>10	11	5(45.5)	1.224(0.344-4.354)	1.219(0.272-5.471)	0.796
Household monthly income					
≤50.000YR	53	17(32.1)	Reference		
> 50.000YR	37	20(54.1)	2.491(1.047-5.926)	0.427(0.176-1.037)	0.039*
Father's education levels					
Educated	69	27(39.1)	Reference		
Illiterate	21	10(47.6)	1.414(0.529-3.781)	1.414(0.529-3.781)	0.490
Mother's education levels					
Educated	47	13(27.7)	Reference		
Illiterate	43	24(55.8)	3.304(1.373-7.948)	7.169(2.070-14.829)	0.008*
Father's occupational status					
Employee	60	26(43.3)	Reference		
Unemployed	30	11(36.7)	0.757(0.307-1.864)	0.451(0.118-1.717)	0.545
Awareness of schistosomiasis					
Yes	32	11(34.4)	Reference		

No	58	26(44.8)	1.551(0.634-3.794)	1.492(0.423-5.268)	0.336
Towel used after swimming					
Yes	55	11(20.0)	Reference		
No	35	26(74.3)	11.556(4.227-31.586)	7.827 (2.416-25.354)	0.001*
Farm helper (father's farm)					
No	63	23(36.5)	Reference		
Yes	27	14(51.9)	1.958(0.783-4.898)	0.369(0.082-1.655)	0.151
History of schistosomiasis					
No	54	12(22.2)	Reference		
Yes	36	25(69.4)	7.955(3.657-20.698)	9.063(1.454-56.504)	0.003*
Practice swimming					
No	36	5(13.9)	Reference		
Yes	54	32(59.3)	9.018(3.034-26.807)	12.727(2.069-78.279)	0.006*
Wearing shoes during water contact					
Yes	50	8(16.0)	Reference		
No	40	29(72.5)	0.072(0.026-0.202)	8.237(2.621-25.883)	0.004*
Defecate near water source					
No	62	15(24.2)	Reference		
Yes	28	22(78.6)	11.489(3.927-33.616)	20.037(2.465-162.874)	0.005*
Presence of sanitation					
Yes	46	6(13.0)	Reference		
No	44	31(70.5)	15.897(5.426-46.581)	17.169(5.672-51.968)	0.005*
Have blood with stool n=36					
No	14	5(35.7)	Reference		
Yes	22	20(90.9)	18.00(2.920-110.957)	32.18(3.191-327.794)	0.002*

Source of household water					
Safe source (pipe)	30	14(46.7)	Reference		
Unsafe source (stream, rain, well, etc.)	60	23(38.3)	1.304 (0.532-3.208)	0.364(0.035-3.834)	0.400
Washing clothes or utensil in open water source					
Yes	58	21(36.2)	Reference		
No	32	16(50.0)	1.850(0.767-4.464)	4.617(0.450-47.351)	0.198
Presence of family member					
Yes	43	21(48.8)	Reference		
No	47	16(34.0)	0.541(0.231-1.264)	0.518(0.217-1.232)	0.137

Discussion

The present study revealed a high *Schistosoma mansoni* IgG seropositivity (41.1%) (37/90; 95% CI: 31.5%–51.4%) among participants which is in agreement with historical data from Ibb's Assahul Valley (35%)⁽¹³⁾ and Al-Mahweet (35.7%)⁽¹⁵⁾. These findings are in agreement with the reported burden of schistosomiasis in Area of Yemen, which is generally reported to range from 19% to 31% in endemic districts according to previous school-age surveys. These results suggest that Schistosomiasis remains an important public health problem in endemic area⁽¹²⁾ despite ongoing control efforts. Our results were significantly higher than the recent study in Taiz (14.3%)⁽¹⁶⁾ and Ethiopia (20.6%)⁽¹⁷⁾ but much lower than 76.3% in Sa'dah⁽¹⁸⁾. Such differences are likely to be explained by regional differences in water-contact behaviours, sanitation infrastructure and health literacy. Furthermore, the strong association between open defecation and infection seen here supports the work of Taiz, strengthening the association between poor sanitation and parasite transmission⁽¹⁹⁾. The Taiz study identified defecating near water sources as a major risk factor⁽¹⁶⁾, since this allows for the contamination of freshwater bodies by *S. mansoni* eggs, perpetuating the parasite's life cycle. Our results indicate that environmental and behavioral factors, including lack of sanitation, swimming in open water, and not wearing shoes during water contact, were independently associated with anti-*S. mansoni* IgG seropositivity. These results confirm patterns documented in Kenya⁽²²⁾ and Ethiopia⁽²³⁾, and are further bolstered by research identifying swimming as a primary risk factor⁽²⁴⁾ and poor sanitation as a persistent driver of transmission⁽¹²⁾.

Socioeconomic and educational factors also are important in the transmission of schistosomiasis in Yemen. Parental literacy and awareness directly impact the community's activities to mitigate the risk of infection, as several studies have shown. For example, an assessment of knowledge, attitudes and practices (KAP) among rural Yemeni families showed that education levels were strongly linked with the adoption of preventive measures. ^(12,20).

Higher maternal education was linked to reduced *S. mansoni* seropositivity in the current study. These findings reinforce our finding that maternal education is a strong protective factor, as the children of educated mothers are significantly less likely to be infected. This suggests that increased maternal literacy results in better preventive practices and reduced exposure, underscoring the importance of incorporating behavior-change communication into mass drug administration programs.

The clinical analysis showed a strong association of the presence of bloody stools with *S. mansoni* infection, as reported previously from the governorate of Taiz ⁽¹⁶⁾. This result may be due to persistent intestinal schistosomiasis, which is known to cause intestinal hemorrhage in affected individuals. Also, participants previously infected with schistosomiasis were more likely to be seropositive, a statistically significant trend also observed in Nigeria ⁽²¹⁾. Variables such as gender and general knowledge of the disease, however, were not significantly associated with the overall rates of infection in this study. The seropositivity rate was higher in males than in females but the difference was not statistically significant. This emphasizes the need for integrated control strategies such as the periodic mass treatment of school-age children as recommended by WHO.

The strong correlation of anti-*S. mansoni* IgG seropositivity with lack of wearing shoes during water contact also reflects the importance of exposure to cercariae-infested water in disease transmission. In the present study, household monthly income but not gender was significantly associated with anti-*S. mansoni* IgG seropositivity. However, studies from Niger have demonstrated that males are more heavily infected with *S. mansoni* than females ⁽²⁵⁾. This difference has been ascribed to greater recreational and occupational water exposure in males. Similarly, no statistically significant association between gender and seropositivity was observed in the present study. However, males in Yemen are more involved in water-related activities such as swimming and working in agriculture, which may increase their exposure to *S. mansoni*.

The results provide strong serological evidence of current or past exposure to *S. mansoni* in the study population. Serology results indicate ongoing exposure to *S. mansoni*, but active transmission was not specifically assessed, as no parasitological, molecular, or longitudinal investigation was conducted. Therefore, the potential for continued transmission should be considered in the larger epidemiological context and deserves further study.

Conclusion

Participants from the Al-Sanahi area, Baddan District, Ibb Governorate, Yemen, frequently had anti-*Schistosoma mansoni* IgG seropositivity, indicating significant prior or ongoing exposure to *S. mansoni*. Numerous socioeconomic, behavioral, sanitation, and water-contact traits were linked to seropositivity. However, the results should not be regarded as estimates of ongoing infection or as proof of causative risk factors because the study was cross-sectional, used convenience sampling, contained a very small sample, and relied solely on IgG serology. To describe the present burden and transmission of schistosomiasis in the area, larger population-based investigations utilizing parasitological and/or molecular diagnostic techniques are necessary.

Limitation of the study

When reading this study, one should keep in mind that it has some limitations. Firstly, the cross-sectional nature of our study limits the ability to identify causal relationships between the identified risk factors and *S. mansoni* infection. The observed correlations are cross-sectional, and therefore do not permit us to establish the temporal sequence of exposure and infection. Second, diagnosis was only by anti-*S. mansoni* IgG ELISA. ELISA is a sensitive tool for the detection of schistosomiasis exposure, however IgG antibodies may remain for months or years after treatment or previous infection. Therefore, seropositivity does not necessarily equate to active infection which may overestimate the current seroprevalence. Serological tests can also cross-react with antibodies produced against other helminth infections. Third, the relatively small sample size ($n = 90$) limits the statistical power of the study and may reduce the precision of the estimated associations. The small number of participants also limits the generalizability of the results to other districts or governorates in Yemen. Fourth, the behavioral and environmental risk factors were collected via self-reported questionnaires, which could be affected by recall bias and reporting bias. Some behaviors concerning water contact and sanitation practices may have been under-reported or over-reported by participants. Fifth, the study was conducted in one single rural community and it may not be representative of the epidemiological situation in other endemic areas of Yemen with different environmental, socioeconomic and cultural features. Finally, parasitological confirmation by stool examination techniques such as Kato–Katz, point-of-care circulating cathodic antigen (POC-CCA) testing or molecular methods were not performed due to logistic and resource constraints. Future research with these diagnostic tools will provide more precise estimates of active infection and transmission dynamics. Despite these limitations, the study provides important baseline data on schistosomiasis exposure and associated risk factors in an understudied endemic area of Yemen, and provides valuable evidence for future disease control and elimination efforts.

Declarations

Consent for Publication

Not applicable.

Data Availability

The datasets used and analyzed during the current analysis available from the corresponding author on

reasonable request.

Competing Interests

The authors declare no competing interests.

Funding

This study received no specific funding.

Clinical Trial Number

Not applicable.

Author Contributions

L Alareqi : Investigation, Methodology, Project Administration, Writing – Review & Editing. H Basha, R Alareqi: L Alareqi, H Basha, R Alareqi, A Basha: Conceptualization, Data Curation, Formal Analysis, Writing – Original Draft. L Alareqi: Supervision, Validation, Visualization, Writing – Review, Editing and Corresponding Author.

Corresponding Author

Correspondence to Lina Mohammed Al-areqi.

Acknowledgments

The authors gratefully acknowledge the support and cooperation of the Al-Sanahi village community administration. They also wish to extend their appreciation to the Health and Population Office in Badan District, Ibb governorate, for their valuable assistance. In addition, the authors thank all participants for their involvement in this study and sincerely appreciate the efforts of the students who contributed to sample collection and questionnaire distribution and also, I would like to thank my student team for help with data collection. They include Ahmed Abdurakeeb Hassan, Nabeel Abdurhman Qaid, Ahmed Khalid Alhomeri, Sadiq Nassr Abdullah, Abdullah Mansour Abdullah Abdu, Yousif Hamood Muhammad, Amer Saleh Mohammed, Yousif Sadeq Ali, Ebrahim Mohammad Kayid.

Ethical considerations

The Research and Ethics Committee (REC) of Ibb University's Faculty of Medicine and Health Sciences gave its approval to this study protocol (Ethical Approval No. 56). After outlining the goal and significance of the study, permission was also acquired from the Health and Population Office, Baddan District, Ibb Governorate. Prior to participation, all adult subjects provided written informed permission. Parents or legal guardians of participants under the age of eighteen provided signed informed permission. Participants and/or their parents or legal guardians were informed about the nature, goal, and methods of the study, and participation was entirely voluntary.

References

1. Amenu, K., Getachew, T., Bekele, A., Defar, A., Taddesse, M., Teklie, H., ... & Kebede, A. (2017). Neglected Tropical Diseases (NTD) service availability at health facilities in Ethiopia: Evidence from 2014 Ethiopian service provision assessment. *Ethiopian Journal of Health Development*, 31(1), 378–383.
2. World Health Organization. (2022). *WHO guideline on control and elimination of human schistosomiasis*. World Health Organization.
3. World Health Organization. (2004). Prevention and control of schistosomiasis and soil transmitted helminthiasis: World Health Organization/Unicef joint statement (No. WHO/CDS/CPE/PVC/2004.9). World Health Organization.
4. The World Bank (2015). Projects and operations. Yemen schistosomiasis. <http://www.worldbank.org/projects/P113102/yemen-schistosomiasis?lang=en>.
5. Colley, D. G., Fleming, F. M., Matendechero, S. H., Knopp, S., Rollinson, D., Utzinger, J., ... & Binder, S. (2020). Contributions of the Schistosomiasis Consortium for Operational Research and Evaluation (SCORE) to schistosomiasis control and elimination: key findings and messages for future goals, thresholds, and operational research. *The American journal of tropical medicine and hygiene*, 103(1 Suppl), 125.
6. Olveda, D. U., Li, Y., Olveda, R. M., Lam, A. K., Chau, T. N., Harn, D. A., ... & Ross, A. G. (2013). Bilharzia: pathology, diagnosis, management and control. *Tropical medicine & surgery*, 1(4) Olveda, D. U., Olveda, R. M., McManus, D. P., Cai, P., Chau, T. N., Lam, A. K., ... & Ross, A. G. (2014). The chronic enteropathogenic disease schistosomiasis. *International Journal of Infectious Diseases*, 28, 193–203.
7. Nelwan, M. L. (2019). Schistosomiasis: life cycle, diagnosis, and control. *Current Therapeutic Research*, 91, 5–9.
8. Jauréguiberry, S., Paris, L., & Caumes, E. (2010). Acute schistosomiasis, a diagnostic and therapeutic challenge. *Clinical microbiology and infection*, 16(3), 225–231.
9. Gray, D. J., Ross, A. G., Li, Y. S., & McManus, D. P. (2011). Diagnosis and management of schistosomiasis. *Bmj*, 342.
10. Woldeyohannes, D., Sahiledengle, B., Tekalegn, Y., & Hailemariam, Z. (2021). Seroprevalence of Schistosomiasis (*S. mansoni* and *S. haematobium*) and its association with gender of school age children in Ethiopia: A systematic review and meta-analysis. *Parasite epidemiology and control*, 13, e00210.
11. Hotez, P. J., & Fenwick, A. (2009). Schistosomiasis in Africa: an emerging tragedy in our new global health decade. *PLoS neglected tropical diseases*, 3(9), e485.
12. Sady, H., Al-Mekhlafi, H. M., Atroosh, W. M., Al-Delaimy, A. K., Nasr, N. A., Dawaki, S., ... & Surin, J. (2015). Knowledge, attitude, and practices towards schistosomiasis among rural population in Yemen. *Parasites & vectors*, 8(1), 436.
13. Raja a, Y. A., Assiragi, H. M., Luhom, A. A. A., Mohammed, A. S., Albahr, M. H., Ashaddadi, M. A., & Muflhi, A. N. A. (2000). Schistosomes infection rate in relation to environmental factors in school

- children. Saudi medical journal, 21(7), 635–638.
14. Al-Murisi, W. M., Al-Mekhlafi, A. M., Mahdy, M. A., Al-Haidari, S. A., Annuzaili, D. A., & Thabit, A. A. Q. (2022). Schistosoma mansoni and soil-transmitted helminths among schoolchildren in An-Nadirah District, Ibb Governorate, Yemen after a decade of preventive chemotherapy. *Plos one*, 17(8), e0273503.
 15. Alwabr, G. (2016). Seroprevalence and associated factors of schistosomiasis among primary schoolchildren in Al-Mahweet Governorate, Yemen. *Banat's Journal of Biotechnology*, 7(13).
 16. Al-Kabab, A. A., Elsheikh, E., & Al-Mikhlafty, A. A. (2023). Community-based seroprevalence of intestinal schistosomiasis and associated risk factors in two endemic districts of Taiz governorate, Yemen. *Medicine Updates*, 13(13), 85–107.
 17. Essa, T., Birhane, Y., Endris, M., Moges, A., & Moges, F. (2013). Current status of Schistosoma mansoni infections and associated risk factors among students in Gorgora town, Northwest Ethiopia. *International Scholarly Research Notices*, 2013.
 18. Nagi, M. A., Kumar, A., Mubarak, J. S., & Bamashmoos, S. A. (1999). Epidemiological, clinical and haematological profile of schistosomiasis in Yemen. *EMHJ-Eastern Mediterranean Health Journal*, 5(1), 177–181, 1999.
 19. Alharazi, T., Bamaga, O. A., Al-Abd, N., & Alcantara, J. C. (2020). Intestinal parasitic infection: seroprevalence, knowledge, attitude, and practices among schoolchildren in an urban area of Taiz city, Yemen. *AIMS Public Health*, 7(4), 769.
 20. Al-Haidari, S. A., Mahdy, M. A., Al-Mekhlafi, A. M., Al Murisi, W. M., Thabit, A. A. Q., Al-Amad, M. A., ... & Al Serouri, A. (2021). Intestinal schistosomiasis among schoolchildren in Sana'a Governorate, Yemen: Seroprevalence, associated factors and its effect on nutritional status and anemia. *PLoS Neglected Tropical Diseases*, 15(9), e0009757.
 21. Dawaki S, Al-Mekhlafi HM, Ithoi I, Ibrahim J, Abdulsalam AM, Ahmed A, Sady H, Atroosh WM, Al-Areeqi MA, Elyana FN, Nasr NA, Surin J. Prevalence and risk factors of schistosomiasis among Hausa communities in Kano State, Nigeria. *Rev Inst Med Trop Sao Paulo*. 2016;58:54. doi:10.1590/S1678-9946201658054.
 22. Handzel, T., Karanja, D. M., Addiss, D. G., Hightower, A. W., Rosen, D. H., Colley, D.G., ... & Secor, W. E. (2003). Geographic distribution of schistosomiasis and soiltransmitted helminths in Western Kenya: implications for anthelmintic mass treatment. *The American journal of tropical medicine and hygiene*, 69(3), 318–323.
 23. Tazebew, B., Temesgen, D., Alehegn, M., Salew, D., & Tarekegn, M. (2022). Seroprevalence of *S. mansoni* Infection and Associated Risk Factors among School Children in Guangua District, Northwest Ethiopia. *Journal of Parasitology Research*, 2022.
 24. Sady H, Al-Mekhlafi HM, Mahdy MA, Lim YA, Mahmud R, Surin J (2013). Seroprevalence and associated factors of Schistosomiasis among children in Yemen: implications for an effective control programme. *PLoS Negl Trop Dis*. 7(8):e2377. doi:10.1371/journal.pntd.0002377.

25. Garba, A., Pion, S., Cournil, A., Milet, J., Schneider, D., Campagne, G., ... & Boulanger, D. (2010). Risk factors for *Schistosoma haematobium* infection and morbidity in two villages with different transmission patterns in Niger. *Acta tropica*, 115(1–2), 84–89.

Figures

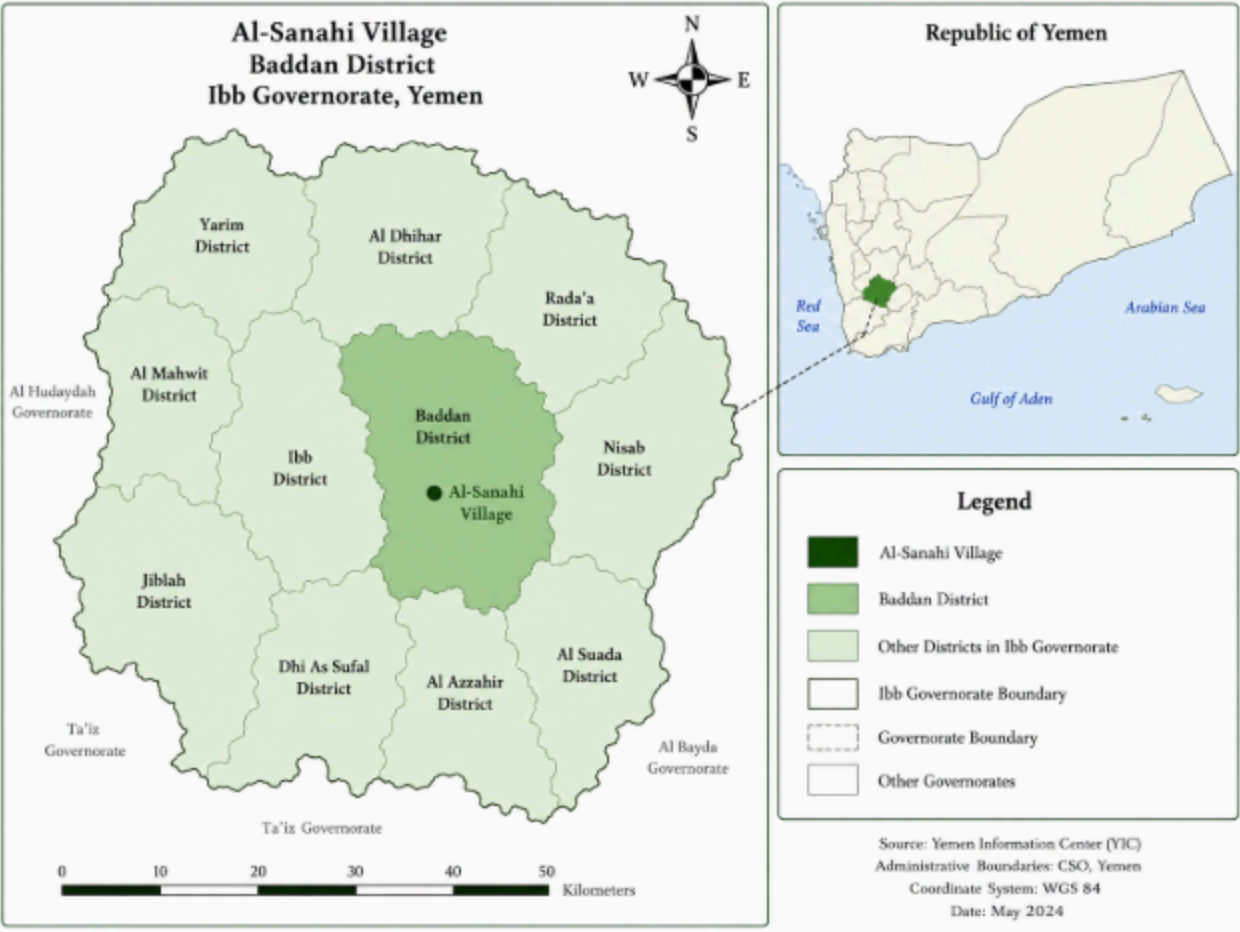


Figure 1

Map of the study area showing Al-Sanahi area, Baddan District, Ibb governorate, Yemen. The map was prepared using QGIS.