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“ Community-based prevalence of intestinal schistosomiasis and associated risk factors in two endemic districts of Taiz governorate, Yemen”

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Abstract:

Schistosomiasis is still a major public health problem despite launching preventive chemotherapy campaigns through yearly treatment of school-age children since 2008. **Objectives:** to identify prevalence, severity, and risk factors of intestinal schistosomiasis in Al-Shmaytin & Al-Mwaset districts-Taiz governorate's-Yemen. **Methods:** A cross-sectional study using structured questionnaires to collect data: age, gender, marital status, education, income, location, occupation, behavioral features, duration of contact with water, clinical background, schistosomiasis awareness, and the results of stool investigation. SPSS version 24 was used for statistical analysis. **Results:** *S. mansoni* prevalence was (14.3%), with a higher prevalence in Al-Mwaset 22.0% compared to Al-Shmaytin 6.9%. Most infections were of high intensity (43.3%). The overall geometric mean egg count was 241.5 EPG. AOR for: district 2.7 (95% CI: 0.94–7.59), ($p=0.000$); marital 0.4 (95% CI: 0.15–0.96), ($p=0.041$); receiving Praziquantel® 0.7 (95% CI: 0.28–1.63), ($p=0.218$); having dam near home 1.2 (95% CI: 0.43–3.55), ($p=0.69$); age 0.2 (95% CI: 0.09–0.61), ($P=0.003$); having pools/ponds near home 4.2 (95% CI: 0.99–17.90), ($p=0.05$); defecate near water sources 2.6 (95% CI: 1.09–6.33), ($p=0.003$), blood in stool 4.7 (95% CI: 0.08–0.59), ($p=0.004$). **Conclusions:** The residents in the study areas were at moderate risk of developing intestinal schistosomiasis. The infection was more prevalent in Al-Mwaset, ages 6-18, single, living near pools/ponds or dams, defecating near water sources (has the main role), having blood with stool, and didn't receive Praziquantel®. The heavy intensity of infection was noted among most of the infected community, male, aged more than 18 years. It was recommended that Praziquantel® be regularly given to communities.

1. Introduction

Schistosomiasis is a snail-borne, parasitic disease caused by six species of blood trematodes belonging to the genus *Schistosoma*: *S. mansoni*, *S. haematobium*, *S. japonicum*, *S. mekongi*, *S. intercalatum* and *S. guineensis* (1). Human Schistosomiasis is one of the neglected tropical diseases (NTDs) that are preventable but still prevalent in developing and poor countries (2), particularly in rural areas. Globally, schistosomiasis affects almost 204 million people, and over 700 million people live in endemic countries (3). Nevertheless, its public health impact is often underestimated as a result of its insidious chronicity and uneven distribution in endemic areas (4). Schistosomiasis mainly prevails in poor and underserved communities with limited access to healthcare services, unsafe water supplies, poor sanitation, and inadequate education (5). Its elimination has therefore been a priority alongside what NTDs stand for in achieving the United Nations' Millennium Development Goals (MDGs) on sustainable poverty reduction in endemic countries (6). Yemen is one of the least developed countries in the world, being ranked 183 out of 191 countries and territories according to the latest United Nations Human Development Index in 2022 (7). Since 2015, armed conflicts have made the country one of the world's worst humanitarian crises. The economy has deteriorated sharply, with the country's output falling by about 40% compared to the pre-conflict level (8). Projections suggest that over three-quarters of the entire population is living below the poverty line (9). Yemen is one of the most afflicted countries with NTDs (10). Schistosomiasis is still a major public health problem

despite launching preventive chemotherapy campaigns to eliminate schistosomiasis through yearly treatment of school-age children since 2008 (11). Mass drug administration (MDA) with Praziquantel is the principal public health intervention in the national control and elimination strategy, with 14 campaigns have been implemented in the country between 2010 and 2017 (12).

Both *S. mansoni* and *S. haematobium* are prevalent in Yemen (13). Although regular and repeated treatments with Praziquantel (PZQ) have resulted in a nationwide decline of schistosomiasis, foci with a high prevalence of infection are still present (14-16). However, infection with either species is heterogeneous across endemic areas of the country. *Schistosoma mansoni* was first reported from Aden in two patients descending from Taiz governorate in the southwest of the country in 1923 (17). In Taiz, both types of schistosomiasis have been documented in humans and snails in the early 1950s (18). In 2014, a national survey revealed an overall prevalence of 3.5% (range 0-38.9% by district) for infection with schistosomiasis, 0.71% (0-10.2% by district) for *S. haematobium* and 2.5% (0-35.7% by district) for *S. mansoni* (19). According to a recently published school-based national mapping survey, 31.6% and 54.2% of 332 districts of the country were identified as endemic for *S. haematobium* and *S. mansoni*, respectively (20).

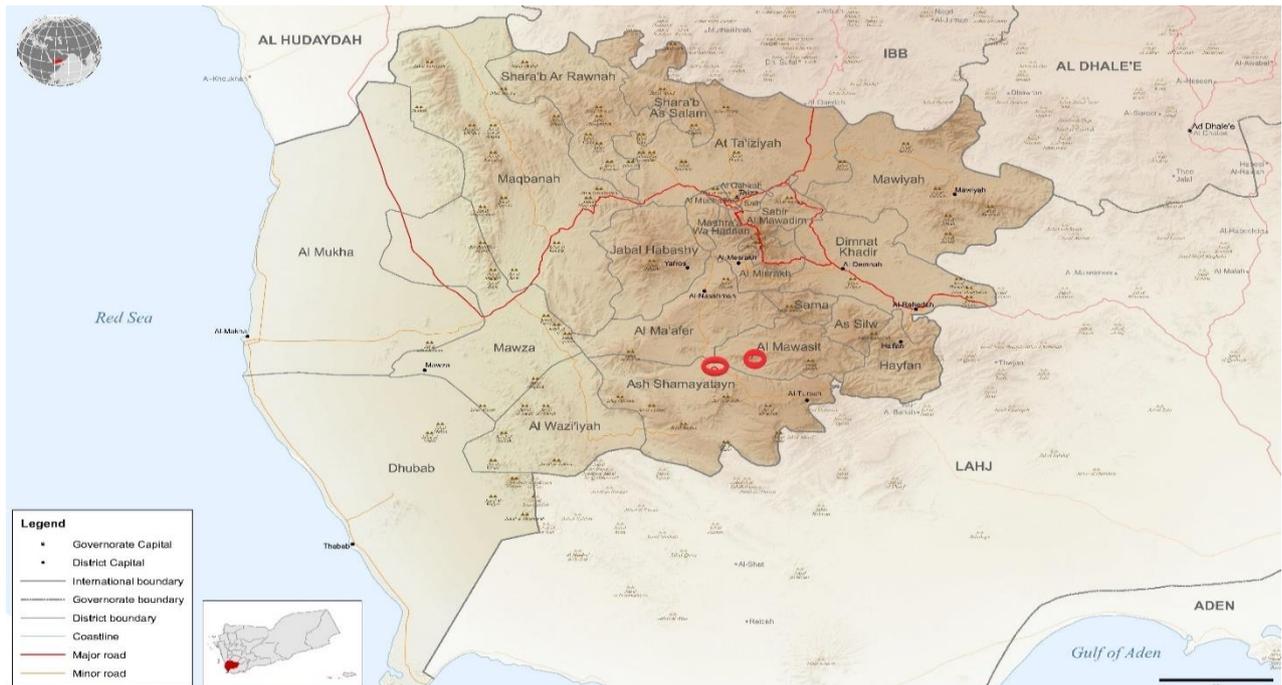
The impact of the situation imposed by armed conflicts and humanitarian crises on the epidemiology of schistosomiasis is largely unknown in many endemic areas of the country. Therefore, the present study aimed to determine the prevalence of intestinal schistosomiasis and identify its associated risk factors in two highly endemic districts of Taiz governorate.

2. Methods

2.1. Study design and setting

A cross-sectional, community-based study was conducted in the Al-Shmaytin and Al-Mwaset districts in the southern part of Taiz governorate during the period from 21st Mar. until 10th April 2021. Taiz is located to the southwest of the country, approximately 256 km south of Sana'a at the coordinates of 13°34'44"N latitude 44°01'19"E longitude. It is the most populated governorate in the country, with an estimated total population of 3.4 million people (21), with approximately 77.5% being urban residents. It is one of the country's governorates most afflicted by the political instability and ongoing war, with the worst water shortages that are forcing residents to frequently access open water sources such as streams, unprotected swimming pools, tanks, and cement cisterns/troughs for drinking and household use purposes. Additionally, the government has built numerous dams across the country for groundwater recharging and agricultural irrigation, exposing people to the risk of schistosomiasis. The risk of schistosomiasis in Taiz governorate, including the Al-Shmaytin and Al-Mwaset districts, is classified as being moderate with a threshold of 10% to less than 50% for any type of schistosomiasis (20). However, the epidemiology of schistosomiasis

following the mass drug administration (MDA) campaigns in the study districts is vague as a result of the ongoing conflict in the country.



Map (1): Taiz Governorate (○ study areas) (22)

2.2. Study population

People aged 6 years or older from both genders, residents in Alsafiah valley of Al-Shmaytin and Ayfoa'a valley of Al-Mwaset who agreed to participate voluntarily and return the samples were included in the study after obtaining written informed consent during the period from 21st Mar. until 10th Apr. 2021. Meanwhile, unwilling persons and those who either refused to give informed consent did not return stool samples and those who were psychiatric patients were excluded from the study if they refused. Although 298 individuals received stool containers, only 258 (86.6%) individuals delivered the containers for examinations.

2.3. Research Ethics

The study proposal was approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, University of Science and Technology, Yemen (MECA No.: (EAC/UST227)). Written informed consent was obtained from all study participants. All information was subjected to the rules of confidentiality. The parents of the children were informed about the study objectives and methods and the priority of the consent for the inclusion of children. Thus, written and signed or thumb-printed informed consent was obtained from all adult participants before starting the survey. Similarly, written and signed or thumb-printed informed consents were taken from parents or guardians, on behalf of their children. All the infected respondent was treated with a single dose of 40 mg/kg body-weight Praziquantel tablets.

2.4. Estimation of Sample Size:

The number of study subjects was estimated by using the minimum sample size determination technique (23), using the formula: $n = (Z^2 * P(1 - P))/e^2$ (24)

Where "n" was the number of sample size, "Z = value from standard normal distribution corresponding to desired confidence level (Z=1.96 for 95% CI), P was the expected proportion: 20.8% from a previous study (25), and e was desired precision (0.05).

$$=(1.96^2 * 0.208(1-0.208))/0.05^2 =253$$

We want this study to have 80% power and a type I error of 5% of predisposing factors in schistosomiasis prevalence in the Al-Shmaytin and Al-Mwaset districts (including the comparison between the two districts). To minimize sampling error during sample collection, at least 17% of the estimated value (45 individuals) was added as a contingency for non-response and missing data. Therefore, we selected 298 out of 8,098 people living in the selected areas to be interviewed and examined.

2.5. Sampling technique:

Twenty-four villages from Alsafiah and Ayfoa'a valleys were selected by systemic random sampling from the available list of villages in the Al-Shmaytin and Al-Mwaset districts, respectively. Then, 298 people were selected by systemic random sampling from the available lists of residents.

2.6. Data collection:

Sociodemographic and clinical characteristics as well as behaviors and risk factors associated with intestinal schistosomiasis were collected using a pre-designed questionnaire (all possible risk factors for schistosomiasis prevalence were included in the questionnaire to improve its validity) through face-to-face interviews. Stool samples were collected into clean, screw-capped containers pre-labeled with the participant's name, age, and identification number besides the date and time of collection after instructing them on the proper collection of the samples.

2.7. Stool examination:

Stool samples were examined for the detection of *S. mansoni* eggs and the estimation of infection intensity as egg per gram (EPG) of stool using the Kato-Katz technique (26, 27). Infection intensity was then classified based on WHO's criteria as light (1–99 EPG), moderate (100–399 EPG), and heavy (>400 EPG) (28).

2.8. Data analysis:

Using IBM SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). Univariate analysis with Pearson's chi-square or Fisher's exact test was used to test the association of sociodemographic characteristics, clinical

features, and risk factors with intestinal schistosomiasis, together with reporting the odds ratios (ORs) and 95% confidence intervals (CIs) of the associations. To identify the independent predictors of intestinal schistosomiasis, a multivariable logistic regression analysis was used for the factors found to be significant in univariate analysis, reporting adjusted ORs (AORs) and their associated 95% CIs. Statistical significance was considered at p-values <0.05.

3. Results

3.1. Characteristics of the study population

About 298 individuals were invited to participate in our study. Out of these, 258 individuals provide stool samples (response rate = 86.6%) and fulfilled the inclusion criteria, and participated in this study.

Table (1) shows that; most respondents were females (65.4%), from the age group 6-18 years 61.4%. Most of them from Alsafiah valley 50.7% while 49.3% from Ayfoa'a valley. Most of them were married and were having essential school education 65.4%. About 61.1% were a student and all were having low monthly incomes of less than 50,000 Yemeni Rial. Most respondents did not have sanitation 72.1% and about 20.5% did not have a toilet in their house. Only 12.1% did not have a fixed hot water supply and 94% lived in a valley or near a stream/spring water source.

Table (1): Characteristics of the study population

Characteristics		n (%)	Characteristics		n (%)
Gender	Male	103 (34.6)	Educational status	Illiterate	77 (25.8)
	Female	195 (65.4)		Essential School	195 (65.4)
Age (years)	6-18	183 (61.4)		Secondary School	23 (7.7)
	>18	115 (38.6)	Diploma/University degree	3 (1)	
Habitatio n	Alsafiah	151 (50.7)	Occupation	Student	183 (61.4)
	Ayfoa'a	147 (49.3)		Housewife	73 (24.5)
Marital Status	Single	207(69.5)		Farmer	21 (7)
	Married/ Divorced/Widow	91 (30.6)		Unemployed	14 (4.7)
Sanitation	Yes	83 (27.9)		Others	7 (2.3)
	No	215 (72.1)	Fixed hot water supply	Yes	262 (87.9)
Toilet in house	Yes	237 (79.5)		No	36 (12.1)
	No	61 (20.5)	Living in valley /near stream	Yes	280 (94.0)
Monthly income < 50,000 YR	100 (100)	No		18 (6.0)	

* The total number was 298.

3.2. Prevalence and intensity of intestinal schistosomiasis

Table (2) shows that *S. mansoni* was more prevalent at 14.3% among people resident in the rural communities of Taiz governorate, with a higher prevalence in the Al-Mwaset district compared to Al-Shmaytin district (22.0% vs. 6.9%, respectively). The odds ratio of 1.2 indicates that the Al-Mwaset district is 1.2 times more likely to have *S. mansoni* compared to the Al-Shmaytin district.

Table (2): Prevalence of intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

Prevalence of intestinal schistosomiasis	<i>N</i>	<i>n</i> (%)	OR	95% CI
Al-Mwaset district	127	28 (22.0)	(r1)	
Al-Shmaytin district	131	9 (6.9)	0.3	(0.15–0.63)
Overall	258	37 (14.3)		

N, number examined; *n*, number infected; OR, odds ratio; CI, confidence interval.

Figure (1) illustrate ($n= 16$ heavy, 10 moderate and 11 light intensity of infection) that most infections with *S. mansoni* in the study districts were of high intensity (43.3%), followed by comparable proportions of light and moderate intensity infections, 29.7%, and 27%, respectively. The overall geometric mean egg count in EPG was 241.5.

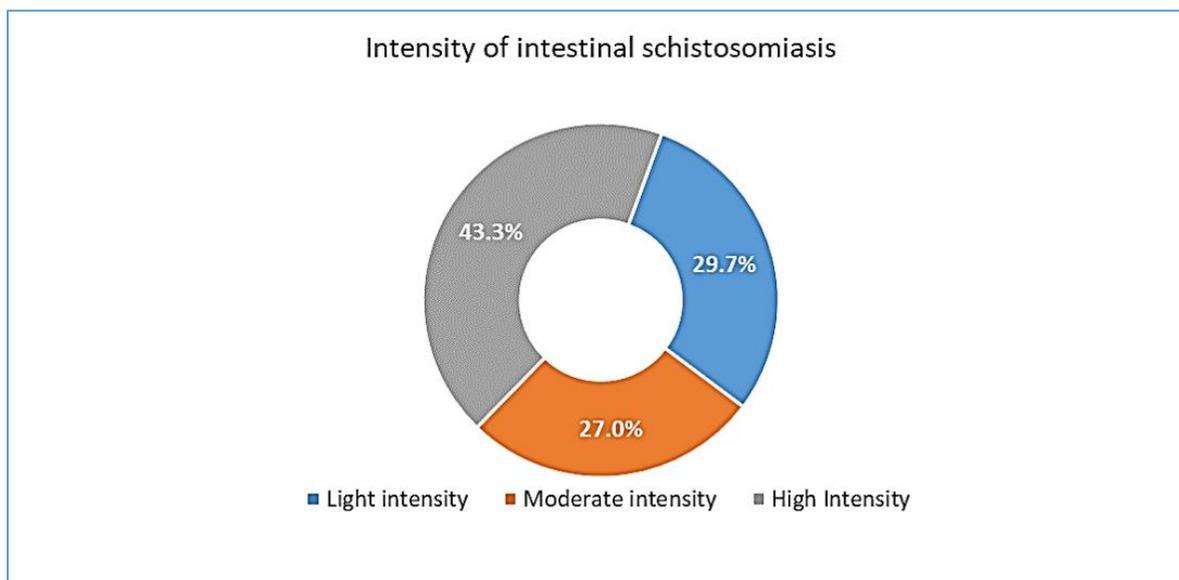


Figure (1): Intensity of intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

3.3. Intensity of intestinal schistosomiasis by district, gender and age

Table (3) shows that more than half of infections with *S. mansoni* among respondents from the Al-Shmaytin district were of heavy intensity (55.6%), followed by light (33.3%) and moderate (11.1%) intensities. However, most infections among respondents from the Al-Mwaset district were of heavy intensity (39.3%), followed by moderate (32.1%) and light (28.6%) intensities. Half of the infections with *S. mansoni* among males were of heavy intensity, followed by moderate (37.5%) and low (12.5%) intensities. However, most infections among females were of light intensity (42.9%), followed by heavy (38.1%) and moderate (19.0%) intensities. Most infections with *S. mansoni* among the age group 6-18 years were of heavy intensity (38.7%), followed by light (37.5%) and moderate (12.5%) intensities. However, most infections among the age group >18 years were of heavy intensity (66.7%), followed by moderate (33.3%) intensities.

Table (3): Intensity of intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021) by district, gender, and age

Variable	N	Intensity of infection n (%)		
		Light	Moderate	Heavy
District				
Al-Shmaytin	9	3 (33.3)	1 (11.1)	5 (55.6)
Al-Mwaset	28	8 (28.6)	9 (32.1)	11 (39.3)
Gender				
Male	16	2 (12.5)	6 (37.5)	8 (50.0)
Female	21	9 (42.9)	4 (19.0)	8 (38.1)
Age (years)				
6-18	31	11 (35.5)	8 (25.8)	12 (38.7)
>18	6	0 (0.0)	2 (33.3)	4 (66.7)

N, number infected; n, number of infected according to classes of intensity

3.4. Factors associated with intestinal schistosomiasis

Tables (4: a and b) reveal that *S. mansoni* was more prevalent among male respondents (16/86, 18.6%) than female respondents (21/172, 12.2%), which was statistically not significant ($p=0.167$). It was more prevalent among 6-18-year age group respondents (31/162, 19.1%) than among >18 years' age group respondents (6/96, 6.3%), which was statistically significant ($p=0.004$). Furthermore, it was common among single (31/178, 17.4%), which was statistically significant ($p=0.036$). It was more prevalent among respondents from the Al-Mwaset district (28/127, 22%) which was statistically significant ($p=0.001$), among essential school respondents (33/171, 19.3%) which was statistically not-significant ($p=0.017$) because 1 or more cell/s have expected count less than 5 and among those with low monthly income (37/258, 14.3%).

Additionally, it was more prevalent among those: did not have sanitation (31/188, 16.5%) which was statistically not-significant ($p=0.107$), residence near water sources (37/241, 15.4%) which was statistically not-significant ($p=0.081$), have pool/ponds near home (34/205, 16.6%) which was statistically significant ($p=0.043$), have dam near home (19/90, 21.1%) which was statistically significant ($p=0.023$), have water pump near home (22/135, 16.3%) which was statistically not-significant ($p=0.348$), were using stream water for 3 years or more (29/176, 16.5%) which was statistically not-significant ($p=0.152$), did not engaged in irrigation (34/220, 15.5%) which was statistically not-significant ($p=0.825$), did not washing clothes in the valley (29/160, 18.1%) which was statistically not-significant ($p=0.081$), bathing/swimming in water collections (27/144, 18.8%) which was statistically not-significant ($p=0.066$), feel itching after water contact (19/101, 18.8%) which was statistically not-significant ($p=0.197$), did not wear shoes during water contact (30/170, 17.6%) which was statistically not-significant ($p=0.107$), and defecate near water sources (22/77, 28.6%) which was statistically -significant ($p=0.000$).

Table (4 a): Socio-economic factors associated with intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

Variables	Infection with <i>S. mansoni</i>				
	<i>N</i>	<i>n</i> (%)	OR	(95% CI)	<i>p</i> -value
Gender					
Male	86	16 (18.6)	1 (r)		0.167
Female	172	21 (12.2)	0.9	(0.83–1.04)	
Age (years)					
6-18	162	31 (19.1)	1 (r)		0.004*
>18	96	6 (6.3)	0.9	(0.79–0.95)	
Marital Status					
Single	178	31 (17.4)	1 (r)		0.036*
Married/ Divorced/Widow	80	6 (7.5)	0.9	(0.81–0.98)	
District					
Al-Mwaset	127	28 (22.0)	1 (r)		0.001*
Al-Shmaytin	131	9 (6.9)	0.3	(0.15–0.63)	
Educational status					
Illiterate/Essential School	237	36 (15.2)	1 (r)		0.191
Secondary School & more	21	1 (4.8)	0.9	(0.80–0.99)	
Monthly Income < 50,000 Y.R.					
Yes	258	37 (14.3)			

N, number examined; *n*, number infected; OR, odds ratio; CI, confidence interval; *Significant association ($P=,0.05$ or less) &

**Non-Significant association because 1 or more cell/s have expected count less than 5.

Table (4 b): Socio-economic factors associated with intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

Variables	Infection with <i>S. mansoni</i>					<i>p</i> -value
	<i>N</i>	<i>n</i> (%)	OR	(95% CI)		
Sanitation						
No	188	31 (16.5)	1 (r)			
Yes	70	6 (8.6)	0.5	(0.23–1.19)		0.107
Residence near water sources						
Yes	241	37 (15.4)	1 (r)			
No	17	0 (0.0)	0.0	(0.00–0.00)		0.081
Pools/ponds near home						
Yes	205	34 (16.6)	1 (r)			
No	53	3 (5.7)	0.9	(0.81–0.97)		0.043*
Dam near home						
Yes	90	19 (21.1)	1 (r)			
No	168	18 (10.7)	0.9	(0.78–1.00)		0.023*
Water pump near home						
Yes	135	22 (16.3)	1 (r)			
No	123	15 (12.2)	1.0	(0.86–1.05)		0.348
Duration of using water						
≥3 yrs	176	29 (16.5)	1 (r)			
<3 yrs/no	82	8 (9.8)	0.6	(0.28–1.24)		0.152
Engagement in irrigation						
No	220	34 (15.5)	1 (r)			
Yes	15	2 (13.3)	0.9	(0.23–3.25)		0.825
Washing clothes in the valley						
No	160	29 (18.1)	1 (r)			
Yes	75	7 (9.3)	0.5	(0.24–1.12)		0.081
Bathing/swimming in water collections						
Yes	144	27 (18.8)	1 (r)			
No	91	9 (9.9)	0.9	(0.81–1.00)		0.066
Feel itching after water contact						
Yes	101	19 (18.8)	1 (r)			
No	134	17 (12.7)	0.9	(0.83–1.04)		0.197
Wear shoes during water contact						
No	170	30 (17.6)	1 (r)			
Yes	65	6 (9.2)	0.5	(0.23–1.20)		0.109
Defecate near water sources						
Yes	77	22 (28.6)	1 (r)			
No	158	14 (8.9)	0.8	(0.68–0.91)		0.000*

N, number examined; *n*, number infected; OR, odds ratio; CI, confidence interval; *Significant association (P=,0.05 or less).

Table (5) shows that *S. mansoni* was more prevalent among those who did not complain previously from schistosomiasis (35/222, 15.8%), no family member complaining of schistosomiasis previously (30/191, 15.7%), have complained of blood with stool during the last two weeks (12/37, 32.4%), have complained from abdominal pain/diarrhea during the last two weeks (26/146, 17.8%), and among those who did not receive Praziquantel® drugs (18/120, 15%), did not know about schistosomiasis (29/193, 15%), did not know about schistosomiasis prevention (31/213, 14.6%).

Table (5): Knowledge and clinical background factors associated with intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

Variables	Infection with <i>S. mansoni</i>				<i>p</i> -value
	<i>N</i>	<i>n</i> (%)	OR	(95% CI)	
Have schist. previously	No	222	35 (15.8)	1 (r)	0.105
	Yes	36	2 (5.6)	0.4 (0.09–1.40)	
Family member having schist. previously	No	191	30 (15.7)	1 (r)	0.291
	Yes	67	7 (10.4)	0.7 (0.31–1.44)	
Have blood with stool during the previous 2 weeks	Yes	37	12 (32.4)	1 (r)	0.001*
	No	221	25 (11.3)	0.8 (0.61–0.96)	
C/O abdominal pain/diarrhea during the previous 2 weeks	Yes	146	26 (17.8)	1 (r)	0.070
	No	112	11 (9.8)	0.9 (0.85–1.00)	
Receive Praziquantel® drugs	Yes	138	19 (13.8)	1 (r)	0.000*
	No	120	18 (15.0)	0.8 (0.68–0.91)	
Type of near HF	Public	257	37 (14.4)	1 (r)	0.682
	Private	1	0 (0.0)	0.0 (0.00–0.00)	
Knowing about schistosomiasis	Yes	65	8 (12.3)	1 (r)	0.589
	No	193	29 (15.0)	1.0 (0.87–1.08)	
Knowing about schist. prevention	Yes	44	6 (13.6)	1 (r)	0.884
	No	214	31 (14.5)	1.0 (0.87–1.13)	

N, number examined; *n*, number infected; OR, odds ratio; CI, confidence interval; *Significant association ($P=,0.05$ or less).

3.5. Independent predictors of intestinal schistosomiasis

Table (6) shows the results of the logistic regression analysis. This table indicates how much each of the independent variables contributes to predicting/explaining the outcome variable. This table also indicates the adjusted Odds Ratio (OR) and its 95% confidence interval (CI). The B values (column 3) indicate the logistic regression coefficients for the variables in the model .

The table shows the adjusted OR, 95% CI for the adjusted OR, and *p*-value (Sig.). The adjusted OR for the district (Al-Mwaset) was 2.7 (95% CI: 0.94– 7.59), which was statistically significant ($p=0.000$). The same adjusted OR for the age (> 18 years) was 0.2 (95% CI: 0.09–0.61), which was statistically significant ($p=0.003$). While, the adjusted OR for persons who have received Praziquantel® drugs was 0.7 (95% CI: 0.28–1.63), which was statistically not significant ($p=0.218$). The adjusted OR for persons who were having a dam near home was 1.2 (95% CI: 0.43–3.55), which was statistically not significant ($p=0.69$). AOR for marital status (married/divorced) was 0.4 (95% CI: 0.15–0.96), which was statistically significant ($P= 0.041$). The adjusted OR for having a pool/pond near home was 4.2 (95% CI: 0.99–17.90), which was statistically significant ($p=0.05$). Similarly, the adjusted OR for defecating near water sources was 2.6 (95% CI: 1.09–

6.33), which was statistically significant ($p=0.003$). The adjusted OR for having blood in stool during the last two weeks was 4.7 (95% CI: 0.08– 0.59), which was statistically significant ($p=0.004$) .

The variable contributed most to the model, according to Wald statistics. From those factors which were statistically significant, defecating near water sources was the most important variable that contributed to the model (the prevalence of *S. mansoni*) since it had the highest Wald value.

Table (6) Independent predictors of intestinal schistosomiasis among people in Al-Shmaytin and Al-Mwaset districts of Taiz governorate (2021)

Predictor	AOR	(95% CI)	P-value
District (Al-Mwaset)	2.7	(0.94– 7.59)	0.000*
Age (years)	0.2	(0.09–0.61)	0.003*
Marital Status	0.4	(0.15–0.96)	0.041*
Pool/ponds near home	4.2	(0.99–17.90)	0.052*
Dam near home	1.2	(0.43– 3.55)	0.695
Defecate near water sources	2.6	(1.09– 6.33)	0.003*
Have blood in stool	4.7	(0.08– 0.59)	0.004*
Receive Praziquantel® drugs	0.7	(0.28– 1.63)	0.218

AOR, adjusted odds ratio; CI, confidence interval; *Significant association ($P=0.05$ or less).

4. Discussion

Most respondents from both valleys: were from the age group 6-18 years, which may be because most people in Yemen were of this age group (people more than 60 years old only represent 4% of the population in Yemen in 2009) (29). Female and this is explained by the fact that female is more cooperative in response to the questionnaire and also due to that most respondents were female. Single, which was due to that, most respondents in this study were from age groups 6-18 years. Essential school students and this result were due to the same reason in the previous variable. Low income (less than 50000 Yemeni Rial). This result reflects the economic status of the country and this indicates the influence of economic level on the prevalence of schistosomiasis in both valleys (more than 61% of people in Taiz governorate are under the poor line in 2008) (29). Moreover, this result was normal as most people in Yemen were unemployed (more than 49% of people in Taiz governorate are unemployed in 2004) (29). Did not have sanitation or sewage. This result may be due to a low economic state, which lead to the inability of the population to have proper sanitation; also, the government did not have enough resources to construct public sanitation. Living directly in the valley or near a stream/spring (most of them at a distance of 300 meters or less). Because most people in rural areas in Yemen depend mainly on the water for domestic purposes.

The prevalence of intestinal schistosomiasis in the research area (14.34%) was considered a moderate risk of morbidity according to the International Statistical Classification of Diseases and Related Health Problems, and Clinical descriptions and case definitions for the WHO's recommended preventative and control strategies for communicable diseases (30,31). There was a moderate risk of morbidity due to the reported parasitologically confirmed cases, which have a prevalence of 10% or more but less than 50% in the afflicted areas, and the necessity of preventative chemotherapy (32). There were ponds and streams in the majority of these villages in the study area, where it was noted that women and children spent the majority of their time playing, bathing, swimming, washing, and gathering water for domestic use. The reported 37 cases may have been substantially impacted by the area's poor access to drinking water and deteriorating medical facilities. This moderate risk of morbidity because the current investigation was conducted in regions that were subject to active control. Three campaigns could be to blame for the moderate prevalence of *S. mansoni* infections, which were carried out between 2015 and 2021 using temporary facilities like schools for drug distribution in the community. Today, all of Yemen's governorates are thought to have an endemic level of intestinal and urinary schistosomiasis, with a prevalence range of 14 to 49 % (10,30). According to a recent study among children from the Taiz governorate, *S. mansoni* was more common than *S. haematobium* (20.7% versus 7.4%) (33), which was similar to our study. Similar results were found in another study conducted among students in the Ibb governorate (34). Our study revealed a lower prevalence of *S. mansoni* than studies conducted in the Hajah, Ibb, and Sana'a governorates (75.3%, 57.0%, and 54.3%, respectively) (35, 36, 37). Additionally, our study results were lower than that (90.0%) reported among school children from the Al-Mahweet governorate (16).

Our results indicate that a bigger percentage of the infected community had a heavy intensity of infection, followed by comparable proportions of light and moderate intensity infections. The overall geometric mean egg count in EPG was 241.54. These results may be due to that; some community members refuse to receive drugs during mass administration therapy (or may be due to drug resistance or malabsorption). Our findings, in contrast to studies conducted in Ethiopia, found that the prevalence of *S. mansoni* was 35.7%, and only 8.9% of the study participants had a heavy intensity of infection (38, 39).

Variations in community water contact activities could easily account for these results. However, some genetic variables that are significant in illness risk could account for this variation (40).

Our study revealed that more than half of infections with *S. mansoni* among respondents from the Al-Shmaytin district were of heavy intensity, followed by light and moderate intensities. While, the highest infections among respondents from the Al-Mwaset district were of heavy intensity, followed by moderate and light intensities. This may be due to that, the infected people in the Al-Shmaytin district have more water contact than those people infected in the Al-Mwaset district (even though most infected people were from the Al-Mwaset district).

Anyway, we discovered that *S. mansoni* among males exhibited a heavier intensity than among females. *mansoni*. This result may be due to that; males have more contact with water than females. These were consistent with numerous reports from other countries (40). The rate of heavy intensity of infection observed (43.24%) must be regarded as public health concern because it may be a sign of the degree of worm burden and, if not treated promptly, will have an increasing impact on egg excretion, which will directly affect the children's physical health and capacity for thought. The disparities in the social and vocational responsibilities played by girls—who frequently accompany their moms to water sources for fetching or other daily chore activities like washing—possibly be the reason why males and females have different light intensities of infection. According to reports of a study on gender-related differences in the impact of tropical diseases on women, there was a higher rate of light intensity in females than in males (41), which is inconsistent with our findings.

According to the age the heavy intensity of *s. mansoni* eggs were highest among the age group >18 years. This result may be due to that, the age group >18 years has a long duration of contact (years) with water. The WHO's roadmap for NTD aims to control schistosomiasis by 2020, which is defined as achieving less than 5% of heavy-intensity infections, and to eliminate schistosomiasis as a public health issue by 2025, which is defined as achieving <1% prevalence of heavy-intensity infections in school-aged children (5–14 years old) (42).

Our study shows that the heavy intensity of infection was observed to be the highest, followed by the light intensity of infection, then the moderate intensity of infection.

WHO 2020 target is far from being met by the total heavy-intensity infection rate for *S. mansoni* infections in this study. As a result, the observed heavy-intensity infection rate may suggest that the *s. mansoni* infection is still a significant public health issue in the research area, making it challenging to meet the WHO's aim of eliminating schistosomiasis by 2020. Therefore, in addition to the existing program's single control measure approach, other high-risk populations must be treated, hygiene and sanitation must be improved, and a clean water supply (43) must be provided in order to avoid transmission.

The findings of our study revealed that *S. mansoni* was prevalent among respondents from the Al-Mwaset district. This may be due to that, most people in study areas in Al-Mwaset districts live directly or near water sources. There was a significant relationship between *s. mansoni* infection and habitation .

In terms of gender, the current study reported a positive (risk) correlation between *s. mansoni* and gender, with boys having greater prevalence rates of the infection than females despite the difference not being statistically significant. These were in line with numerous findings from studies conducted in Yemen and other countries (20, 38, 39, 40). However, other studies also found that males typically had greater prevalence rates of schistosomiasis than females, and this was explained by factors such as water contact

habits or religious and cultural considerations (44,32,45,46,47). Females, on the other hand, are in charge of fetching water, washing clothes, and using these water sources to clean utensils, thus they are similarly exposed to infective stages. Yemen has one of the largest gender gaps in schooling in the entire globe, and female education continues to be a major challenge (48). Other studies found comparable results (49, 50, 51). This research supports a study from Southern Ethiopia that found *S. mansoni* prevalence was greater in male participants (26.5%, 417/1572) than in female participants (25.0%, 198/815), however, the difference was not statistically significant (52). The present study found that children aged 6-18 years and single respondents were the most likely to contract the disease, which were statistically significant. This prevalence was comparable with earlier research done in Yemen (53, 25, 54). Because they swim, fish, gather water, and walk through contaminated water to and from school, children between the ages of 6 and 17 are particularly affected by the disease (55). This was consistent with earlier findings from Yemen and other countries (53, 45, 46, 56,57). Children at this age wander around a lot and maybe more exposed to contaminated water, which could help to explain this while playing, swimming, fetching water for the house, or helping with agricultural tasks. Most of these children were seen being carried to a brook with their mothers for a bath. When younger children accompany their older siblings to bodies of water, they run the risk of contracting an infection while learning to swim. Swimming, without wearing shoes when using stream water, and using water for long period, and lack of water supply projects in some of the villages were claimed to increase a child's chance of contracting an illness in the area. This may be due to that; the body was in contact for a longer period in these activities. Residents were exposed to disease since they were forced to rely on streams because of the shortage of that resource. Moreover, the high levels of parental carelessness and illiteracy that have been seen in the region may hinder parents from teaching their children about preventative measures, which could affect the pattern of transmission. Furthermore, it was common among single and essential school respondents. This was due to the same reasons for infection among 6-18 years' children .

According to our findings, poverty has an impact on how intestinal schistosomiasis was prevalent. This might be a result of how it reduces access to health services for the communities. Similar to how improper sanitation and home latrines, which were evident in the study area, can contaminate water sources and raise the risk of transmission. An estimated 170 million people in sub-Saharan Africa, and a further 30 million in North Africa, Asia, and South America, suffer from schistosomiasis, which is generally associated with rural poverty (58).

It was common among residents near water sources and/or having water pumps near home, which increase the access to the source of infection even though it is not statistically significant. Similarly having pool/ponds and/or dam near home which were statistically significant. Moreover, it was common among those using stream water for 3 years or more, and/or those using water for bathing/swimming in water collections, and/or those who did not wear shoes during water contact. These results indicate the role of water contact for a long

time or frequently in the prevalence of *S. mansoni*. The relationship between water and schistosomiasis was also highlighted in a previous study (59).

Our study shows that, *S. mansoni* was common among those who defecate near water sources which were statistically significant. This explain the reasons for enhancing the transmission of schistosomiasis due to lack of access to improved sanitation which contributes to open defecation, which results in environmental contamination. This in consistent with findings of study in south Côte d'Ivoire (60). *S. mansoni* was more prevalent among those who did not know about schistosomiasis and/or those who did not know about schistosomiasis prevention. This indicates the role of knowledge in the prevalence of *S. mansoni*, even though it was statistically not significant. Inadequate knowledge about schistosomiasis' causes, transmission, symptoms, and prevention among Yemen's rural population may be a challenging barrier to the disease's elimination in such areas. A low level of knowledge about signs and symptoms was also reported among the rural population in Yemen, in Mwea (61). In addition to the present MDA, health education in schools and communities is essential within these communities to greatly lower the transmission and morbidity of schistosomiasis (32).

Our study revealed that *S. mansoni* is common among those who have complained of blood with stool and those who have complained of abdominal pain/diarrhea during the last two weeks. Infected individuals were significantly more likely to report the presence of bloody diarrhea and fatigue/malaise within 2weeks preceding the interview reported in two selected kebeles in Bedeno district, Ethiopia (38). Moreover, *S. mansoni* was common among those who did not receive Praziquantel® drugs. The use of effective chemotherapy was the mainstay for the prevention and control of schistosomiasis at individual and community levels (26). *S. mansoni* was more prevalent in those who did not receive Praziquantel® medication during MDA and in people who were unaware of how to prevent schistosomiasis. According to WHO classification (30), the prevalence of intestinal schistosomiasis among communities, primarily children, was found to be low risk of morbidity in Alsafiah valley and moderate risk of morbidity in Ayfoa'a valley.

From the aforementioned factors and to identify the main factors (predictors), We discuss it according to the adjusted OR: Ayfoa'a valley from Al-Mwaset district was 2.7 times more likely to have *S. mansoni* compared to Alsafiah valley from Al-Shmaytin district after adjusting (or controlling) for age, marital status, pool/ponds near home, dam near home, defecate near water sources, having blood in stool during the last two weeks and receiving Praziquantel® drugs. While, the AOR for age is 0.2, which means that the odds of having *S. mansoni* would decrease by 80% with each year's increase in age after adjusting (or controlling) for habitation/district, marital status, pool/ponds near home, dam near home, defecate near water sources, having blood in stool during the last two weeks and receiving Praziquantel® drugs. Similarly, the AOR for marital status is 0.4, which means that the odds of having *S. mansoni* would decrease by 60% with those who are

married/divorced/widow after adjusting (or controlling) for habitation/ district, age, pool/ponds near home, dam near home, defecate near water sources, having blood in stool during the last two weeks and receiving Praziquantel® drugs. While, persons who have received Praziquantel® drugs were 0.7 times more likely to have *S. mansoni* compared to those who do not have receive Praziquantel® drugs after adjusting for age, habitation/district, marital status, pools/ ponds near home, dam near home, defecate near water sources, having blood in stool during the last two weeks. The same for, persons who have a dam near home were 1.2 times more likely to have *S. mansoni* compared to those who do not have a dam near home after adjusting for age, habitation/district, marital status, pool/ponds near home, have receiving Praziquantel® drugs, defecate near water sources, having blood in stool during the last two weeks. Persons having pools/ponds near home were 4.2 times more likely to have *S. mansoni* compared to those who do not have pools/ponds near home after adjusting (or controlling) for age, habitation/district, marital status, dam near home, defecating near water sources, having blood with stool during the last two weeks and receiving Praziquantel® drugs. This result was in line with the study conducted in Yemen (15). Persons who have defecated near water sources were 2.6 times more likely to have *S. mansoni* compared to those who do not have to defecate near water sources after adjusting (or controlling) for age, habitation/district, marital status, pool/ponds near home, dam near home, having blood with stool during the last two weeks and receiving Praziquantel® drugs. Persons who have blood in stool during the last two weeks were 4.7 times more likely to have *S. mansoni* compared to those who do not have blood with stool during the last two weeks after adjusting (or controlling) for age, habitation/district, marital status, pool/ponds near home, dam near home, defecate near water sources, and receiving Praziquantel® drugs.

5. Conclusion

This study demonstrates a moderate risk of intestinal schistosomiasis morbidity in rural areas of the Al-Shmaytin and Al-Mwaset districts of Taiz, Yemen, and this highlights the significance of current control methods, which include implementing integrated, targeted, and efficient schistosomiasis control measures (mainly MDA). The *S. mansoni* infection is more prevalent in the Ayfoa'a valley/Al-Mwaset district, live near a pool/pond or dam, ages 6-18 years, single, defecate near water sources, have blood in stool during the last two weeks, did not receive Praziquantel®. A bigger percentage of the infected community had a heavy intensity of infection, *S. mansoni* among males exhibited a heavier intensity than females, and the age > 18 years had the greatest rate of heavy intensity. Additionally, this study suggests that further research into the prevalence of *S. mansoni* in additional highly endemic regions is necessary. To stop the infection from spreading to other parts of the governorate, regional control programs are crucial. To combat this sickness in these communities, public health professionals should screen additional family members and provide medical care to the ill. In addition to the regular distribution of medications, health education regarding good personal

hygiene and good sanitary practices, the provision of proper sanitation, and clean and safe drinking water are crucial among these communities to reduce the transmission and morbidity caused by schistosomiasis.

9. Recommendations

The aforementioned findings indicate that the following actions are advised: (i) Praziquantel®-based treatment programs and comprehensive epidemiological research should be implemented throughout the Al-Mwaset/Al-Shmaytin districts and the Taiz governorate as a whole (including preschool children). (ii) To prevent interaction with already infested water bodies, there should be a safe water supply available and recreational water bodies developed in the valleys. (iii) Snail vectors in the region and the governorate need to be identified and controlled. (iv) Health education: With the full involvement of the individual and the community, health education attempts to encourage and reinforce healthy behavior. (v) It is important to foster long-lasting improvements in cleanliness and hygiene to maximize the effects of routine chemotherapy. (vi) The intestinal schistosomiasis elimination campaigns should be incorporated alongside other public health initiatives for tuberculosis, HIV/AIDS, and malaria. (vii) Research in the future should use geographic information systems to pinpoint the specific locations of the affected areas, which will aid in focusing control efforts in the endemic regions.

10. Conflict of interest declaration

The authors stated that there are no interests at odds with one another.

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