sciendo

DOI 10.2478/helm-2022-0032

HELMINTHOLOGIA, 59, 3: 233 – 245, 2022

Intestinal parasitic infection among rural schoolchildren in Taiz, Yemen: School-based assessment of the prevalence and associated risk factors

T. ALHARAZI[1,2]*

[1]Department of Medical Laboratory Sciences, College of Applied Medical Sciences, University of Hail, Hail, Kingdom of Saudi Arabia, *E-mail: *alhraziali@yahoo.com*; [2]Department of Medical Microbiology and Immunology, Faculty of Medicine and Health Sciences, Taiz University, Taiz, Yemen

Article info

Received December 22, 2021
Accepted September 1, 2022

Summary

Yemen is an underdeveloped country plagued by poverty, disease, and social conflicts. Furthermore, most of the population lives in rural areas and is vulnerable to intestinal parasite infections (IPI). School-based cross-sectional studies were conducted between 1 February and 31 March 2019 among schoolchildren in rural communities in the Sabir Almawadim and Almawasit districts of Taiz, southwest Yemen. A structured questionnaire collected information regarding sociodemographic characteristics and risk factors. Wet mount and formol-ether concentration techniques were used to detect and identify intestinal parasites in stool specimens. The stool specimens were collected from each study participant using a clean, leak-proof, and adequately labeled stool cup. Statistical analysis of the data was performed using SPSS version 20. Of the 478 students screened for intestinal parasites, 245 (51.26 %) had at least one parasite. The prevalence of protozoa was higher than helminths (30.3 % versus 20.9 %, respectively). The percentages of single, double, and triple infections were 37.4 %, 4.4 %, and 1.7 %, respectively. *Giardia lamblia* was the most prevalent pathogen (15.5 %), followed by *E. hisrolyrica/dispar* (14.9 %), *Schistosoma mansoni* (13.3 %), *Ascaris lumbricoides* (3.8 %), *Trichuris trichiura* (2.9 %), *and Enterobius vermicularis* (1.3 %). Multivariate analysis confirmed that practicing unwashed hands before eating, open field defecation, unwashed fruits and vegetables, and dirty unclipped fingernails were the most significant predictors of high risk of IPIs (p <0.05). Regarding *Schistosoma mansoni*, multivariate analysis identified the behaviors of practicing swimming in the river/ponds and practicing open defecation, especially near water sources, as independent risk factors for *Schistosoma mansoni* infection among schoolchildren. The current study showed that rural areas in Taiz were significantly infected with IPIs, showing that IPIs remains a significant public health problem in low-income communities. Consequently, prevention efforts should focus on treating and deworming schoolchildren regularly, promoting health education in rural schools, conducting personal hygiene inspections for students, and ensuring that schools have sanitary facilities.

Keywords: Intestinal parasites; Taiz; Yemen; prevalence; risk factors; prevalence; schoolchildren

Introduction

Intestinal parasite infections (IPIs) are a major source of high morbidity and mortality in low-income countries, with millions of people infected with parasitic infections (Pradhan *et al*., 2014; Sitotaw *et al*., 2020). Infections are often a severe health issue in many de-

* – corresponding author

veloping countries, such as Yemen (Efstratiou *et al*., 2017). These countries have infection rates of 30 – 60 %, compared to 2 % in developed countries (Kumar *et al*., 2019).

IPIs are a major public health concern on a global level, affecting primarily children in developing countries (Harhay *et al*., 2010). *G. lamblia* is one of the most prevalent causes of diarrhea globally, accounting for approximately 200 million cases each year and posing the risk of zoonotic transmission (Yaoyu *et al*., 2011). In contrast, *E. histolytica* is one of the most serious intestinal protozoa in terms of morbidity and mortality. It affects approximately 500 million people annually and causes amoebic dysentery and invasive amoebiasis in about 50 million people. It has killed about 100,000 people (Baxt *et al*., 2008). Also, infections by parasitic worms, mainly *Schistosoma and* soil-transmitted Helminthes, remain global burdens in low-income countries (Hotez *et al*., 2014; Mascarini-Serra, 2011).

The persistence of intestinal parasite infections in children has been linked to a variety of environmental and socioeconomic factors. (Bugssa, 2015; Dejenie *et al*., 2010; Mascarini-Serra, 2011). In Yemen, the prevalence of intestinal parasite diseases varies from region to region based on personal and societal hygienic, sanitation, and environmental conditions. (Raja'a *et al*., 2001).

In a few Yemeni provinces, some school-based studies have been carried out, including Taiz (Al-Harazi, 2016; T. Alharazi *et al*., 2020), Sana'a (bin Mohanna *et al*., 2014), Aden (Al-Abd *et al*., 2021), Ibb (Alsubaie *et al*., 2016), Hadhramout (Al-Haddad *et al*., 2010), and Al-Mahweet (Alwabr *et al*., 2016). In one of the earliest large-scale studies on IPIs in Yemen, over 37,000 stool samples were examined from 1980 to 1982, leading to a prevalence rate of 53.0 % (Farag, 1985). A recent study in the urban region of Taiz revealed that 107 (27.8 %) of the 385 children examined for enteric parasites were positive (Alharazi *et al*., 2020). The majority of studies conducted in Taiz took place in urban areas. Many epidemiological studies have been carried out in Yemen, including Taiz, to investigate the prevalence of IPIs (Al-Harazi, 2016; T. Alharazi *et al*., 2020), with only a few studies focusing on the prevalence and distribution of *Giardia* (Al-Mekhlafi, H.M. *et al*. 2017) and *Schistosoma* infections (Alharazi *et al*.,2021). In addition, Taiz has many valleys and streams that provide water for drinking and domestic purposes and are considered major routes for *Giardia* transmission (Hisham *et al*., 2017). Furthermore, the snail vector of schistosomiasis is heavily prevalent in these streams and valleys, creating an environment that facilitates Schistosomiasis transmission (Sady H. *et al*., 2013). Thus, the current study aimed to determine the prevalence of intestinal parasites and risk factors among schoolchildren in rural communities in Taiz, southwestern Yemen.

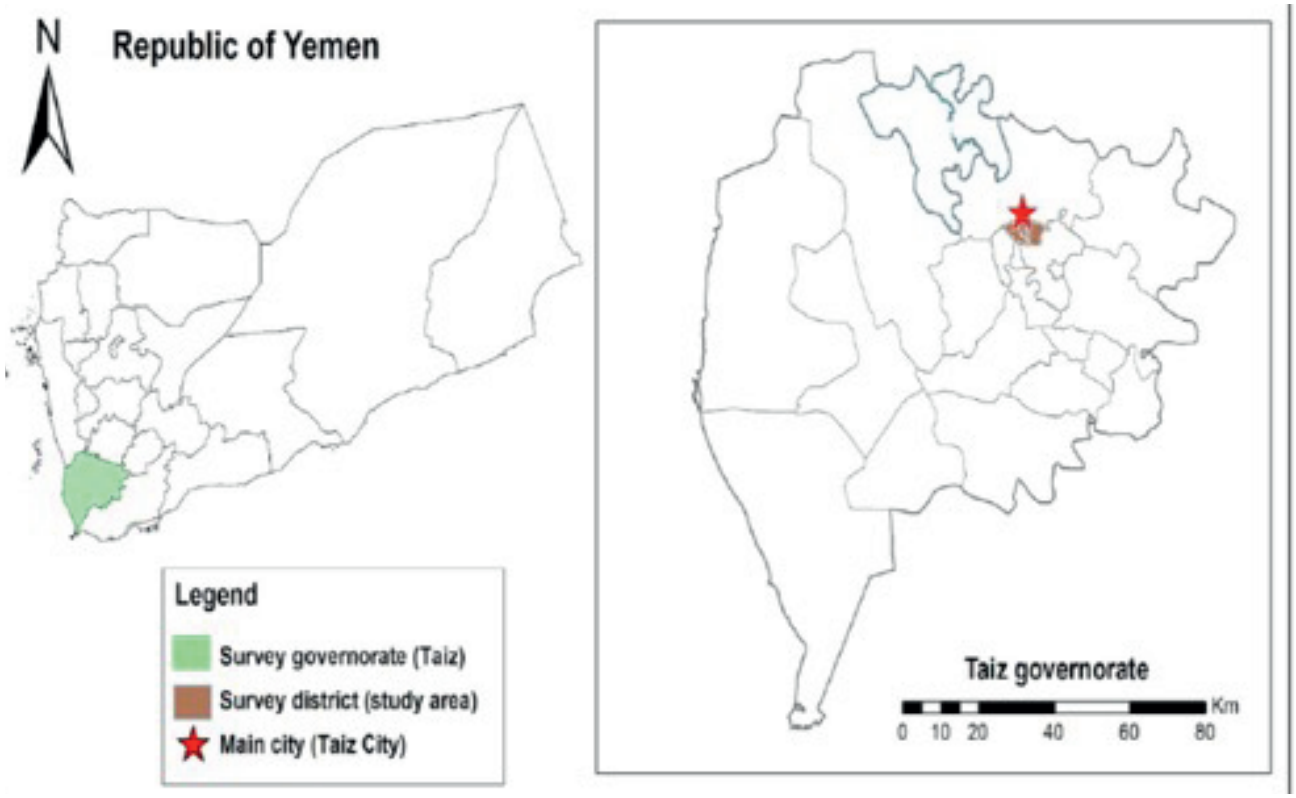

Fig. 1. A geographic map showing the study area (Almawasit & Sabir Almawadim) in Taiz governorate.
The map was created by authors using the Esri ArcGIS 10.7 software

Materials and Methods

Study design and study area

A cross-sectional survey was performed among schoolchildren in rural areas of the western Taiz governorate from 1 February to 31 March 2019. For this study, two rural districts (Almawasit & Sabir Almawadim) were recruited (Fig. 1). Convenience sampling was used to identify rural communities for this study. This was due to a security concern, as most of the districts in this governorate have been under siege since 2015. An official list provided by the Taiz Governorate's General Directorate of Education was then used to select two schools from each district randomly. There are two schools selected, Khalid bin Alwaleed School in the Dhabab area and Saba School in the Aleayn area, both in Sabir Almawadim District. Furthermore, Dhabab Bani Hammad School and 26th September School have been selected from the Almawasit district. The schools were picked based on these criteria: there are over 100 students enrolled; the principal has agreed to be part of the study, and there haven't been any threats of war or kidnapping.

Taiz governorate (44.01°E and 13.34°N) is located in Yemen's southern region, 280 kilometers from the capital Sana'a. It is surrounded on the west by the Red Sea, on the north by the governorates of Hodeida and Ibb, on the south by the governorate of Lahj, and on the east by the governorate of Al-Dhale. It is one of the country's most densely inhabited governorates, with approximately 2.9 million aggregate population and 12,605 km^2 land area. Taiz governorate's people are primarily farmers and merchants. Rural regions of Taiz governorates are dominantly inhabited by nearly 80 % of the population as compared to urban areas (20 %).

Taiz governorate consists of two biological zones: a mountainous highland zone on the east coast and a lowland coastal area on the west coast. The temperature fluctuates between relatively hot and cool during the year, with an average annual temperature of around 26 °C. The humidity level varies between 70 % and 90 %, and the average annual rainfall is about 200 mm. These areas are considered rural, with farmlands that depend on streams, underground wells, and ponds as the primary water source. The schools included in this study are close to valleys with streams, wells, and

Table 1. Socio-demographic characteristics of school children in rural communities of Taiz, Yemen.

Socio-demographic variables	categories	Frequency (n)	Percentage (%)
Age	≤10	344	72
	>10	134	28
Sex	Male	271	56.7
	Female	207	43.3
Parent's educational status	literate	225	47.1
	illiterate	253	52.9
Family size	<5	236	49.4
	≥ 5	242	50.6
Washing hand before meals	Always	148	31.0
	sometimes	330	69.0
Defecation habits	Latrine	153	32.0
	Open field	325	68.0
Eating washed fruits and vegetables	Always	132	27.6
	sometimes	346	72.4
Source of drinking water	Protected tap water	147	30.8
	Unprotected stream/well	331	60.2
Swimming practice in rivers/ ponds	Sometimes	240	50.20
	Always	238	49.8
Washing clothes/utensil in open water sources	Sometimes	261	54.6
	Always	217	45.4
Dirty unclipping Fingernails	Always	144	30.1
	Sometimes	334	69.9
Existing of animals inside the house	No	258	54.0
	Yes	220	46.0

ponds. Most of the population in these areas worked in agriculture, and almost all mothers did-not have a job, while fathers worked as farmers or laborers. Most houses do not have piped water, while only 20 % have electricity (connected to generators only at night).

Study population

Students in four (4) selected schools in rural areas of the Taiz governorate were included in the study. The participants were recruited through convenience sampling. Students attending grades 1 – 9 of formal education who participated in the study were invited to participate when we visited each school.

Of the 520 children eligible for the study, 15 refused to participate, did not provide their parents or guardians with an informed consent form, and 27 did not provide fecal and urine samples. As a result, a total of 478 schoolchildren aged 6 – 15 years old who provided suitable fecal or urine samples for analysis, filled out the questionnaires, and consented to participate in the study, were included in the analysis. Of the 478 students recruited, 118 were from the Khalid bin Alwaleed School, 123 from the Saba School in the Sabir Almawadim district, 112 from the Dhabab Bani Hammad School, and 125 from the 26th September School in the Almawasit district. Most of the children had dirty unclipped fingernails and played outside with bare feet during the visit to the study areas. Some children spend part of their leisure time playing and swimming in streams or pools. In these study areas, poverty is prevalent, and poor housing and living conditions are typical.

Data and stool sample collection

Participants were lucidly informed of the purpose of the study prior to data collection. Parasites were detected by collecting 10 grams of fresh stool samples in screw-capped plastic containers of 100 mg capacity equipped with an applicator stick. The participants were instructed to collect sufficient samples aseptically. Following appropriate safety precautions and standard operating procedures, samples were immediately labeled and transported to the laboratory at ambient temperature. Using a wet mount preparation technique with saline, all stool samples were processed and examined for intestinal parasite cysts, trophozoites, eggs, and larvae using Olympus microscope model CX21 at 100x and 400x magnifications.

A face-to-face interview using a pretested and validated questionnaire was used to solicit information about the sociodemographic (age, gender, family size, and education level of parents) and environmental and behavioral factors (handwashing habits before meals, defecation habits, eating unwashed fruits and vegetables, source of drinking water, the pattern of swimming in a river/pond, washing clothes/utensils in open water, and the presence of animals in the house) (Al-Harazi, 2016).

Stool examination for parasites

Immediately after collection, saline or iodine wet preparations of stool samples were prepared and microscopically inspected using 10X and 40X objectives. Furthermore, stool sediments were examined using a formol-ether sedimentation method, following standard guidelines (Williams, 2000).

Analytical Statistics

The data was analyzed using the IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA). The odds ratio, the 95 % confidence interval, and the *P* value were calculated accordingly. A descriptive analysis of the distribution of the study subjects about the variables was performed. A fitted binary logistic regression analy-

Table 2. Prevalence of intestinal parasitic infections among schoolchildren in rural communities of Taiz, Yemen (2019 – 2020).

Parasite species	Number positive	Percentage (%)
Overall	245	51.26
Protozoa		
Giardia lamblia	74	15.5
E.histolytica/dispar/moshkovskii	71	14.9
Total	145	30.3
Helminths		
Schistosoma mansoni	62	13.0
Ascaris lumbercoid	18	3.8
Trichuris trichiura	14	2.9
Enterobius vermicularis	6	1.3
Total	100	20.9
Single	179	37.4
Double	21	4.4
Triple	8	1.7

Table 3. Distribution of intestinal parasitic infections among schoolchildren in rural communities of Taiz, Yemen (2019 – 2020) according to gender.

Parasite species	Gender[a]		*P* value
	Male n (%)	Female n (%)	
Protozoa			
Giardia lamblia	44 (16.2)	30 (14.5)	0.602
E.histolytica/dispar/moshkovskii	41 (15.1)	30 (14.5)	0.846
Total	85 (31.4)	60 (29.0)	0.786
Helminths			
Schistosoma mansoni	33 (12.2)	29 (14.0)	0.715
Ascaris lumbricoides	11 (4.1)	7 (3.4)	0.700
Trichuris trichiura	6 (2.2)	8 (3.9)	0.289
Enterobius vermicularis	3 (1.1)	3 (1.4)	0.739
Total	53 (19.6)	47 (22.7)	0.462

[a]The total number examined was 271 for males and 207 for females.

sis model was completed after cross-tabulating each explanatory variable with the outcome variable while checking the fulfillment of chi-square assumptions. Univariate analysis was conducted to select variables for multivariate analysis. Finally, bivariate analysis was performed to choose variables for the multivariate analysis. All variables with a *P* value < 0.25 were used for the multivariate analysis utilizing forward stepwise logistic regression and were considered to have a significant association at $P \leq 0.05$.

Ethical Approval and Informed Consent

Human participants were involved in all studies under the institution's ethical committee's ethical standards and the Helsinki Declaration of 1964 and its later amendments.

Results

The sociodemographic features of the participants in the study

A total of 478 students from four (4) primary schools in Almawasit and Sabir Almawadim districts participated in the study. The participants' ages ranged from 6 to 15 years and were divided into two age groups according to a previous study (Mahdy *et al*., 2008) (i.e., 6 – 10 and 11 – 15). The 6 to 10-year-old age group accounted for 72.0 % (344/478) of participation, followed by the 11 to 15-year-old age group, which accounted for 28.0 % (134/478) (Table 1). Males made up more than half of the participants, 56.7 % (271/271). About 47.1 % (225) of the student's parents are literate. Additionally, half of the participants (242/478) were from families with five or more members (Table 1).

Table 4. Distribution of intestinal parasitic infections among schoolchildren in rural communities of Taiz, Yemen (2019 – 2020) according to age.

Parasite species	Age group (years)[a]		*P* value
	≤10 n (%)	>10 n (%)	
Protozoa			
Giardia lamblia	62 (18.0)	12 (9.0)	0.014
E.histolytica/dispar/moshkovskii	58 (16.9)	13 (9.7)	0.061
Total	120 (34.9)	25 (18.7)	0.018
Helminths			
Schistosoma mansoni	41(11.9)	21(15.7)	0.273
Ascaris lumbricoides	17 (4.9)	1 (0.8)	0.032[b]
Trichuris trichiura	10 (2.9)	4 (3.0)	1.000[b]
Enterobius vermicularis	5 (1.4)	1 (0.8)	1.000[b]
Total	73(21.2)	27(20.2)	0.386

[a]The total number examined was 344 for age group ≤10 years and 134 for age group >10 years.
[b]Calculated for Fisher's exact test.

Table 5. Univariate and multivariate analysis of potential risk factors associated with intestinal parasitic infections among schoolchildren in rural communities of Taiz, Yemen

Variables		Infected %	OR (95% CL)	*P* value	AOR (95% CL)	*P* value
Age	>10	31.3	1		1	
	≤10	43.6	1.391 (1.054-1.837)	0.014*	0.903(0.210-1.524)	0.601
Gender	Male	39.1	1			
	Female	41.5	1.106(0.765-1.600)	0.591		
Parent's educational status	educated	41.3	1			
	Non educated	39.1	0.912(0.633-1.316)	0.624		
Family size	>5	41.2	1			
	≤ 5	39.0	1.102(0.764-1.589)	0.602		
Washing hand before meals	Always	31.0	1		1	
	sometimes	44.0	1.753(1.157-2.657)	0.008*	2.07(1.281-3.368)	**0.013***
Defecation habits	Latrine	32.0	1		1	
	Open field	54.7	2.558(1.741-3.757)	0.001*	1.869(1.216-2.874)	**0.004***
Eating washed fruits and vegetables	Always	27.5	1		1	
	sometimes	55.6	3.299(2.252-4.831)	0.001*	0.289(0.010-1.37)	**0.011***
Source of drinking water	Protected tap water	30.7	1		1	
	Unprotected stream/well	52.1	2.457(1.689-3.575)	0.001*	1.09(0.901-2.10)	0.074
Swimming practice in rivers/ ponds	Sometimes	50.0	1		1	
	Always	37.1	0.444(0.293-0.671)	0.074		
Washing clothes/ utensil in open water sources	Sometimes	54.7	1			
	Always	45.3	0.537(0.221-0.937)	0.069		
Dirty unclipping Fingernails	Always	30.1	1		1	
	Sometimes	54.0	2.725(1.868-3.976)	0.001*	0.545(0.352-0.845)	**0.023***
Existing of animals inside the house	No	32.3	1		**1**	
	Yes	53.4	2.395 (1.636-3.507)	0.001*	1.048(0.981-2.639)	0.068

*Statistically significant at $P<0.05$; 1 = reference value; OR = odds ratio; AOR = adjusted odds ratio

Prevalence of IPIs among study participants

As presented in Table 2, the total prevalence of parasitic intestinal infections among 478 examined rural schoolchildren in Taiz was 51.26 % (245/478). Notably, infections of protozoal parasites were predominantly observed over helminthic infections, accounting for 30.3 % (145/478) and 20.9 % (100/478) of all infections, respectively. *G. lamblia* and *E. histolytica/dispar moshkovskii* were the most common IPIs among schoolchildren (15.5 % (74/478) and 14.9 % (71/478), respectively). However, *S. mansoni* was the most common, 13.0 % (62/478) helminth, followed by *Ascaris lumbricoides* 3.8 % (18/478) and *Trichurius trichuria* 2.9 % (14/478). *On* the other hand, *E. vermicularis* was the least common helminth among schoolchildren, 1.3 % (6/478). Most of the students, 37.4 % (179/478), were infected with a single parasite species. In contrast, 4.4 % (21/478) and 1.7 % (8/478) of cases had double and triple infections.

Distribution of parasitic intestinal infections by gender among male and female participants

Table 3 reveals no statistically significant variation in overall protozoa infection rates based on gender. Both males and females were infected with *G. lamblia* at comparable rates (16.2 % vs. 14.5 %, respectively), with no statistically significant differences (*P* =0.602). In contrast, the overall helminthic infections prevalence rate was slightly higher among females (22.7 %) than males (19.6 %) without statistically significant differences (*P* =0.462).

The distribution of parasitic intestinal infections by age (IPIs among various age groups)

Table 4 shows statistically significant differences (*P* < 0.018) between the overall infection rates with protozoa by age group. Schoolchildren aged ≤10 years old, on the other hand, had a significantly higher (P< 0.014) infection rate with *G. lamblia* than those aged >10 years old (18.0 vs. 9.0 %, respectively). Though a higher infection rate of *S. mansoni* was observed among those aged > 10 years old than those aged ≤10 years old (15.7 % vs. 11.9 %, respectively), a significant difference (*P* > 0.05) was not found. In addition, *Ascaris lumbricoides* show a trend of infection rate among those aged ≤10 years old than those aged >10 years old (4.9 % vs. 0.8 %, respectively) with a statistically significant difference (P< =0.032).

Risk factors associated with the prevalence of IPIs

Univariate analysis revealed seven factors associated with intestinal parasite infections (Table 5), including students aged ≤10 (OR= 1.391, 95% CI 1.054–1.837), students who do not practice unwashed hands before eating (OR= 1.753, 95% CI 1.157–2.657), defecate in open field (OR= 2.558, 95% CI 1.157–2.657), eating unwashed fruits and vegetables (OR= 3.299, 95% CI 2.252–4.831), drinking unprotected stream/well water (OR=2.457, 95% CI 1.689–3.575), dirty unclipping fingernail (OR= 2.725, 95% CI 1.868–3.976), and existing of animals inside the house (OR= 2.395, 95% CI 1.636–3.507). All other factors, including gender, family size, parents' education level, swimming in streams, rivers, and ponds, and the use of open water sources in washing clothes and utensils, were not significantly linked to the prevalence of IPIs among schoolchildren. Multivariate analysis using forward stepwise logistic regression confirmed that schoolchildren with unwashed hands were 2.07 times more probably to present IPIs than those with clean hands before (Adjusted OR= 2.077, 95% CI 1.281–3.368), and those who defecated in the open field were twice as likely to get infected with IPs (Adjusted OR=1.869, 95% CI 1.216–2.874). In contrast, schoolchildren who ate washed fruits and vegetables were 0.289 less likely to exhibit IPIs than those who ate unwashed fruits and vegetables, and those who clipped their fingernails (Adjusted OR=0.545, 95% CI 0.352–0.845) were half as likely to exhibit IPIs compared with those with dirty unclipping (Table 5).

Risk factors associated with the prevalence of Giardia lamblia

Additionally, univariate analysis was performed based on a single *Giardia* infection (Table 6). It was found that age, practice of defecation in open fields (OR= 2.094, 95% CI 1.184–3.704), eating unwashed fruits and vegetables (OR= 2.987, 95% CI 1.766–5.052), drinking from unprotected stream water (OR= 4.998, 95% CI 2.833–8.817), washing clothes/utensil in open water sources (OR= 2.082, 95% CI 1.292–3.538), dirty unclipping fingernails houses (OR= 2.137, 95% CI 1.292–3.535), and existing of animals inside houses (OR= 1.967, 95% CI 1.113–3.478) were a significant predictor of giardiasis. Logistic regression analysis confirmed that the practice of defecation in an open field (Adjusted OR= 1.473, 95% CI 0.830–2.522), drinking from unprotected stream water (Adjusted OR= 2.261, 95% CI 0.879–3.473), and eating unwashed fruits or vegetables (Adjusted OR = 1.238, 95% CI 0.133–2.425) were a significant risk factor for *Giardia* infection.

Risk factors associated with the prevalence of Schistosoma mansoni

Regarding the behaviors possibly associated with *Schistosoma mansoni* among schoolchildren, practices such as defecation in open fields (OR = 1.017; 95% CI 0.173–2.947, *P* =0.041), swimming in rivers/ponds (OR = 2.471; 95% CI 1.667–3.046, *P*=0.001), and washing clothes/utensils in open water sources (OR = 2.473; 95% CI 1.260–3.865, *P* =0.013) were significantly associated with *Schistosoma mansoni* infection among schoolchildren. However, eating without washing hands (OR = 0.590; 95% CI 0.309–1.126, *P* = 0.106), eating unwashed fruits and vegetables (OR = 0.681; 95% CI 0.393–1.181, *P* = 0.170), drinking unprotected water (OR = 0.715; 95% CI 0.413–1.240, *P* = 0.213), and dirty unclipping fingernails (OR = 0.685; 95% CI 0.400–1.174, *P* = 0.167) were not significantly associated with *Schistosoma* infection. Multivariate analysis identified that practicing swimming in the river/ponds (adjusted OR = 1.826; CI 1.048–3.183; *P* = 0.034), and practicing open defecation, especially near water sources (adjusted OR =

2.383; CI 1.302–4.363; *P* = 0.005) as independent risk factors for *Schistosoma mansoni* infection among schoolchildren (Table 7).

Discussion

In low-income countries such as Yemen, IPIs remain a challenge to public health. Studies in different settings are essential for identifying and designing effective intervention mechanisms for high-risk communities.

IPIs are highly prevalent among children in rural schools in Taiz (51.26 %), with more protozoal infections than helminthic (30.3 vs. 20.92 %). The results are in accordance with those reported among 330 patients attending general and local hospitals in Taiz urban area, Yemen (Talal Al, 2016). In addition, IPIs have been reported at a higher rate among 1218 primary schoolchildren in rural communities of Sana'a (54.8 %) and 200 schoolchildren in Al-Mahweet governorate (90.0 %), northwest of Sana'a (Alwabr *et al*., 2016). Many other developing countries, including India (49 %), Nepal (51.9 %), Oshoidi Logos, Nigeria (58.3 %), and Burkina Faso (84.7 %), have reported a high prevalence of IPIs among school children (Sitotaw, B. *et al*.,2019). In rural areas of Peru (Choi *et al*., 2017), over 100 % prevalence rates were reported among schoolchildren, proving that IPIs remain a major threat to poor society. According to our study, the infection rate with intestinal parasites is higher than in studies conducted among schoolchildren from Saudi Arabia (27.8 %; Al-Mohammed *et al*., 2010), Egypt (30.7 – 33.6 %) (Abdel Fatah *et al*., 2012), and Oman (38.7 %) (Patel *et al*., 2006). Variations in geography, methodology

Table 6. Univariate and multivariate analysis of potential risk factors associated with *Giardia lamblia* among schoolchildren in rural communities of Taiz, Yemen.

Variables		Infected %	OR (95% CL)	*P* value	AOR (95% CL)	*P* value
Age	≤10	18.0	1		1	
	>10	9.0	0.447 (0.233-0.860)	0.014*	1.403 (0.833-1.890)	0.074
Gender	Male	16.2	1			
	Female	14.5	0.874(0.528-1.0447)	0.602		
Parent's educational status	educated	52.7	1			
	Non educated	47.3	0.766(0.466-1.258)	0.291		
Family size	>5	55.4	1			
	≤ 5	44.6	0.751(0.456-1.236)	0.259		
Washing hand before meals	Always	54.0	1			
	sometimes	14.1	0.859(0.491-1.492)	0.583		
Defecation habits	latrine	11.4	1		1	
	Open field	22.7	2.094(1.184-3.704)	0.001*	1.473(0.830-2.522)	**0.024***
Eating unwashed fruits and vegetables	Always	9.2	1		1	
	Sometimes	23.1	2.987(1.766-5.052)	0.001*	1.238(0.0.133-2.425)	**0.020***
Source of drinking water	Protected tap water	6.7	1		1	
	Unprotected stream/ well	26.5	4.998(2.833-8.817)	0.001*	2.261(0.879-3.473)	**0.037***
Swimming practice in rivers/ ponds	Sometimes	14.8	1		1	
	Always	17.5	0.759(0.442-1.303)	0.485		
Washing clothes/utensil in open water sources	Sometimes	11.5	1		1	
	Always	21.4	2.082(1.292-3.538)	0.004*	0.938(0.071-1.70)	0.084
Dirty unclipping fingernail	always	11.2	1		1	
	Sometimes	21.3	2.137(1.292-3.535)	0.003*	1.041(0.301-1.9400	0.066
Existing of animals inside the house	No	12.0	1		1.	
	Yes	21.3	1.967(1.113-3.478)	0.006*	2.24(0.932-3.12)	0.130

*Statistically significant at *P*<0.05; 1 = reference value; OR = crude odds ratio; AOR = adjusted odds ratio

(sample size, diagnostic methods, study participants), study setting, and study period could be potential reasons for the differences in prevalence. Among schoolchildren, 37.4 % had a single infection, whereas 4.4 % and 1.7 % harbored double and triple infections, respectively. According to Alsubaie *et al*., 2016, parasitic infection among children in Ibb was commonly due to a single parasite species. In contrast, infections due to multiple parasites was shown to be the most common among Al-Mahweet schoolchildren (75.5 %) (Alwabr *et al*., 2016).

This study found no association between gender and the rate of IPIs (P > 0.05) (Table 5). Earlier studies in Taiz (Al-Harazi, 2016), Sana'a (Alyousefi *et al*., 2011), and Al-Mahweet governorate, northwest of Sana'a (Alwabr *et al*., 2016), revealed similar findings.

However, there is substantial evidence that females are less likely to be exposed to IPIs than males (Abdi *et al*., 2017; Alsubaie *et al*., 2016; Hailegebriel, 2017) due to differences in gender roles. Age, on the other hand, was observed to be associated with IPIs (Table 5). Children as young as ten years old or less had a high prevalence rate. According to reports from various areas in Yemen, older children have a lower infection rate. Poor environmental sanitation and personal hygiene are frequently revealed as the main contributors to the increased prevalence of intestinal parasites among study participants (Table 5).

Risk factors associated with the prevalence of IPIs

Unwashed hands habits before eating, open field defecation behavior, eating unwashed fruit and vegetables, lacking safe drinking water, dirty unclipped fingernails, and the presence of animals inside their houses were found to be major risk factors for the prevalence of IPI among school children in this rural area (p < 0.05). These findings are consistent with previous studies performed elsewhere in Yemen, e.g. (Al-Harazi, 2016; Alyousefi *et al*., 2011). The degree of association between IPIs and other risk factors was determined by multivariate logistic regression (Table 5). Unwashed before eating, open field defecation, unwashed fruits and vegetables, and dirty unclipped fingernails were all identified as predictors of IPIs among the study's participants. Participants who defecated in open fields were twice as at risk as those who defecated in latrines. On the other hand, students' practices of washing fruits were found to be significantly related to IPIs. Compared to students who always washed fruits and vegetables, those who did not were three times more likely to become infected. Additionally, students who did not frequently clean and clip their fingernails were about three times as likely to develop IPIs as those who did. These results are consistent with those reported in other studies (Abossie *et al*., 2014; Gebretsadik, 2016; Hailegebriel, 2017).

Risk factors associated with Giardia lamblia

According to Table 2, about 15 % of students were infected with *Giardia lamblia*, followed by *Entamoeba histolytica/dispar and Schistosoma mansoni*. Logistic regression confirmed that open field defecation behavior, eating unwashed fruit and vegetables, and drinking unprotected water were all risk factors for *Giardia lamblia* infection. As a result, the risk of infection with Giardia lamblia was doubled in study subjects who defecated in open fields (OR = 2.094, 95% CI 1.184–3.704 P = 0.001), roughly threefold in those who ate unwashed fruits and vegetables (OR = 2.987, 95% CI 1.766–5.052 P = 0.001), and fivefold in those who drank from unsafe rivers and streams (OR = 4.998,95% CI 2.833–8.817 *P* = 0.001) compared with those who used latrine, not eating unwashed fruits and vegetables, and drank from unsafe rivers and streams (Table 6). Another study found that this parasite had a high prevalence among school children in Yemen (20 – 45 % and 30 – 35 %) and other countries (Alamir *et al*., 2013; Choy *et al*., 2014).

Schoolchildren of 10 years old or younger are significantly more likely to be infected with *Giardia lamblia* than those older than 10 years. This might be because they have relatively poorer personal hygiene habits. Meanwhile, schoolchildren from Hadhramout (16.8 %) and Ibb (14.0 %) had similar infection rates with *Entamoeba histolytica/disorder* dispar (55, 56). However, children from Al-Mahweet and Ibb recorded higher infection rates of 64.0 % and 33.7 %, respectively (Alsubaie *et al*., 2016; Alwabr *et al*., 2016).

Risk factors associated with the prevalence of Schistosoma mansoni

Among the study participants, the third most prevalent parasite was *Schistosoma mansoni,* with 13.0 %. Students' swimming habits in rivers and ponds may account for this high prevalence rate. Additionally, open defecation or urination in or near water may have contributed to *Schistosoma mansoni* infection in study subjects (Table 7). An interesting finding was the absence of *Schistosoma haematobium* in the studied children. These results are consistent with earlier studies conducted in Taiz and other governorates (T. H. Alharazi *et al*., 2021; Alharbi *et al*., 2019; Al-Shamiri *et al*., 2011). In contrast, *S. haematobium* was found to be the predominant species in other governorates, such as Sana'a and Almahweet, rather than *S.* mansoni (Alwabr *et al*., 2016; Hany *et al*., 2015). This variance in species distribution may be explained by the occurrence of suitable freshwater snails that act as the necessary molluscan hosts (Rabone *et al*., 2019; Sady *et al*., 2013). In terms of gender, the current study demonstrated no statistically significant difference in schistosomiasis prevalence between male and female subjects. Furthermore, Sady *et al*., 2013 found that male children with schistosomiasis did not have a significantly higher infection rate than female children.

Of soil-transmitted helminths, only-*A. lumbricoides* and *T. trichiura* were present with a low prevalence rate compared to studies carried out in Al-Mahweet (Alwabr *et al*., 2016), Ibb (Alsubaie *et al*., 2016), and Aden (Al-Abd *et al*., 2021). This may be attributed to the difference in educational levels and climates. Oppositely, hookworms and *S. stercoralis* were not found among schoolchildren in the current study. This is similar to reports from previous studies (Al-Qobati *et al*., 2012; bin Mohanna *et al*., 2014; MB, 2017; Singh

Table 7. Univariate and multivariate logistic of potential risk factors associated with *Schistosoma mansoni* among schoolchildren in rural communities of Taiz, Yemen.

Variables		Infected %	OR (95% CL)	*P* value	AOR (95% CL)	*P* value
Age	≤10	11.9	0.662(0347-1.265)	0.273		
	>10	15.7	1			
Gender	Male	16.2	1			
	Female	14.5	1.175(0.688-2.007)	0.555		
Parent's educational status	educated	13.8	1			
	Non educated	12.3	0.874(0.512-1.490)	0.620		
Family size	>5	13.1	1			
	≤ 5	12.1	1.127(0.660-1.924)	0.661		
Washing hand before eating	Always	13.4	1			
	sometimes	12.0	0.590(0.309-1.126)	0.673		
Defecation habits	latrine	11.1	1		1	
	Open field	16.3	1.017(0.173-2.947)	0.041*	2.383(1.302-4.363	**0.005***
Eating unwashed fruits and vegetables	Always	14.9	1			
	sometimes	10.6	0.681(0.393-1.181)	0.170		
Source of drinking water	Protected tap water	14.6	1			
	Unprotected stream/ well	10.9	0.715(0.413-1.240)	0.231		
Swimming practice in rivers/ ponds	Sometimes	9.4	1		1	
	Always	15.8	2.472 (1.667-3.046)	0.011*	1.826(1.048-3.183)	**0.005***
Washing clothes/utensil in open water sources	Sometimes	8.3	1			
	Always	16.1	2.473 (1.260- 3.865)	0.013*	2.73(1.79-4.015)	0.825
Dirty unclipping fingernail	Always	12.6	1			
	Sometimes	11.3	0.784 (0.437-1.404)	0.412		
Existing animals inside house	Yes	15.7	1			
	No	11.3	0.685 (0.400-1.174)	0.167		

*Statistically significant at *P*<0.05; 1 = reference value; OR = odds ratio; AOR = adjusted odds rati

Khadka *et al*., 2019; Sitotaw *et al*., 2020). However, hookworms and *S. stercoralis* have low prevalence rates in Ibb among schoolchildren, reporting 1.2 % and 0.8 % prevalence rates, respectively (Alsubaie *et al*., 2016).

Prevalence of Enterobius vermicularis, Ascaris lumbricoides and Trichuris trichiura

Although Enterobius vermicularis infections are easily persistent because of autoinfection, the current study found that the prevalence rate was low among rural students in Taiz (1.3 %). Generally, *E. vermicularis* infection was found in children from various Yemeni governorates at rates ranging from 0.8 % to 13.0 % (Al-Haddad *et al*., 2010; Al-Shibani *et al*., 2009; Alsubaie *et al*., 2016; Alwabr *et al*., 2016). In such a susceptible group, it is surprising that *E. vermicularis* were extremely low in prevalence. The low prevalence of *E. vermicularis* was probably due to the inadequacy of the coproparasitological techniques used to detect it.

One limitation of the study was the prevalence of infection with *S. manasoni* and soil-transmitted helminths instead of the intensity of infection. Reasons for this include the lack of resources and the unavailability of Kato-Katz kits on the local market. Additionally, stool specimens were obtained once from each participant, while conventional identification of intestinal parasites requires at least three specimens taken on three different days. Furthermore, due to security concerns, we selected only two rural districts in this governorate (Almawasit & Sabir Almawadim).

Conclusion

The high prevalence rates of IPI infection are a primary concern to public health in low-income neighborhoods where poor sanitation conditions, poor general health practices, inadequate toilet facilities, contaminated food and water, and malnutrition remain. *G. lamblia, E. histolytica/dispar, and S. mansoni* were among the intestinal parasites commonly found in schoolchildren. The most significant risk factors for these infections have been identified as practice unlashing hands before eating, open field defecation, drinking from unsafe water, eating unwashed fruits and vegetables, swimming in rivers or ponds, and having dirty unclipping fingernails. Political leaders must engage in concerted efforts to reduce intestinal parasitic infection rates.

Conflict of Interest

The author states no conflict of interest.

References

Abdel Fatah, N., Nofal, L. (2012): Anthropometric Status, Anemia and Intestinal Parasitic Infections among Primary School Children in Alexandria, Egypt. *J. High Inst. Public Health*, 42(1): 82 – 102. DOI: 10.21608/jhiph.2012.20126

Abdi, M., Nibret, E., Munshea, A. (2017): Prevalence of intestinal helminthic infections and malnutrition among schoolchildren of the Zegie Peninsula, northwestern Ethiopia. *J Infect Public Health*, 10(1): 84 – 92. DOI: 10.1016/j.jiph.2016.02.009

Abossie, A., Seid, M. (2014): Assessment of the prevalence of intestinal parasitosis and associated risk factors among primary school children in Chencha town, Southern Ethiopia. *BMC Public Health*, 14(1): 166. DOI: 10.1186/1471-2458-14-166

Al-Abd, N., Alharazi, T., Bamaga, O.A.A. (2021): Cross-sectional study on the prevalence of intestinal parasitic infections among displaced persons in Yemen. *Electronic Journal of University of Aden for Basic and Applied Sciences*, 2(1): 39 – 48. DOI: 10.47372/ejua-ba.2021.1.88

Alamir, M., Awoke, W., Feleke, A. (2013): Intestinal parasites infection and associated factors among school children in Dagi primary school, Amhara National Regional State, Ethiopia. *Health*, 05(10): 1697 – 1701. DOI: 10.4236/health.2013.510228

Al-Haddad, A.M., Baswaid, S.H. (2010): Frequency of intestinal parasitic infection among children in Hadhramout governorate (Yemen). *J Egypt Soc Parasitol*, 40(2): 479 – 488

Al-Harazi, T. (2016): Prevalence and Risk Factors Associated with Intestinal Parasitic Infection among Patients in Taiz City, Yemen. *Br Microbiol Res J*, 16(3): 1 – 7. DOI: 10.9734/bmrj/2016/28317

Alharazi, T., AA Bamaga, O., Al-Abd, N., C Alcantara, J. (2020): Intestinal parasitic infection: prevalence, knowledge, attitude, and practices among schoolchildren in an urban area of Taiz city, Yemen. *AIMS Public Health*, 7(4): 769 – 777. DOI: 10.3934/publichealth.2020059

Alharazi, T.H., Al-Mekhlafi, H.M. (2021): A cross-sectional survey of the knowledge, attitudes and practices regarding schistosomiasis among rural schoolchildren in Taiz governorate, southwestern Yemen. *Trans R Soc Trop Med Hyg*, 115(6): 687 – 698. DOI: 10.1093/trstmh/traa115

Alharbi, R.A., Alwajeeh, T.S., Assabri, A.M., Almalki, S.S.R., Alruwetei, A., Azazy, A.A. (2019): Intestinal parasitoses and *Schistosome* infections among students with special reference to praziquantel efficacy in patients with schistosomosis in Hajjah governorate, Yemen. *Ann Parasitol*, 65(3): 217 – 223. DOI: 10.17420/ap6503.203

Al-Mekhlafi, H.M. (2017): *Giardia duodenalis* infection among rural communities in Yemen: A community-based assessment of the prevalence and associated risk factors. *Asian Pac J Trop Med*, 10(10): 987 – 995. DOI: 10.1016/j.apjtm.2017.09.011

Al-Mohammed, H.I., Amin, T.T., Aboulmagd, E., Hablus, H.R., Zaza, B.O. (2010): Prevalence of intestinal parasitic infections and its relationship with socio-demographics and hygienic habits among male primary schoolchildren in Al-Ahsa, Saudi Arabia. *Asian Pac J Trop Med*, 3(11): 906 – 912. DOI: 10.1016/S1995-7645(10)60218-0

Al-Qobati, S.A., Al-Maktari, M.T., Al-Zoa, A.M.B., Derhim, M. (2012): Intestinal parasitosis among Yemeni patients with cancer, Sana'a, Yemen. *J Egypt Soc Parasitol*, 42(3): 727 – 734. DOI: 10.12816/0006356

Al-Shamiri, A.H., Al-Taj, M.A., Ahmed, A.S. (2011): Prevalence and co-infections of schistosomiasis/hepatitis B and C viruses among school children in an endemic areas in Taiz, Yemen. *Asian Pac J Trop Med*, 4(5): 404 – 408. DOI: 10.1016/S1995-7645(11)60113-2

Al-Shibani, L.A., Azazy, A.A., El-Taweel, H.A. (2009): Cryptosporidiosis and other intestinal parasites in 3 Yemeni orphanages: prevalence, risk, and morbidity. *J Egypt Soc Parasitol*, 39(1): 327 – 337

Alsubaie, A.S.R., Azazy, A.A., Omer, E.O., Al-Shibani, L.A., Al-Mekhlafi, A.Q., Al-Khawlani, F.A. (2016): The pattern of parasitic infections as public health problem among school children: A comparative study between rural and urban areas. *J Taibah Univ Med Sci*, 11(1): 13 – 18. DOI: 10.1016/j.jtumed.2015.10.006

Alwabr, G.M.A., Al-moayed, E.E. (2016): Prevalence of intestinal parasitic infections among school children of Al-Mahweet Governorate, Yemen. *Eur J Biol Res*, 6(2): 64 – 73

Alyousefi, N.A., Mahdy, M.A.K., Mahmud, R., Lim, Y.A.L. (2011): Factors associated with high prevalence of intestinal protozoan infections among patients in Sana'a city, Yemen. *PLoS One*, 6(7): e22044. DOI: 10.1371/journal.pone.0022044

Baxt, L.A., Singh, U. (2008): New insights into *Entamoeba histolytica* pathogenesis. *Curr Opin Infect Dis*, 21(5): 489 – 494. DOI: 10.1097/QCO.0b013e32830ce75f

bin Mohanna, M.A., Al-Zubairi, L.M., Sallam, A.K. (2014): Prevalence of *Helicobacter pylori* and parasites in symptomatic children examined for helicobacter pylori antibodies, antigens, and parasites in Yemen. *Saudi Med J*, 35(11): 1408 – 1411

Bugssa, G. (2015): A Survey of Intestinal Parasitic Infections among Dega Ochollo Primary School Children, Ochollo, South Ethiopia. *Sci J Public Health*, 3(1): 56 – 60. DOI: 10.11648/j.sjph.20150301.20

Choi, B., Kim, B. (2017): Prevalence and risk factors of intestinal parasite infection among schoolchildren in the peripheral highland regions of Huanuco, Peru. *Osong Public Health Res Perspect*, 8(5): 302 – 307. DOI: 10.24171/j.phrp.2017.8.5.03

Choy, S.H., Al-Mekhlafi, H.M., Mahdy, M.A.K., Nasr, N.N., Sulaiman, M., Lim, Y.A.L., Surin, J. (2014): Prevalence and associated risk factors of *Giardia* infection among indigenous communities in rural Malaysia. *Sci Rep*, 4: 6909. DOI: 10.1038/srep06909

Dejenie, T., Asmelash, T. (2010): Schistosomiasis mansoni among school children of different water source users in Tigray, northern Ethiopia. *Momona Ethiop. J. Sci.*, 2(1): 49 – 60. DOI: 10.4314/mejs.v2i1.49650

Efstratiou, A., Ongerth, J.E., Karanis, P. (2017): Waterborne transmission of protozoan parasites: Review of worldwide outbreaks - An update 2011 – 2016. *Water Res*, 114: 14 – 22. DOI: 10.1016/j.watres.2017.01.036

Gebretsadik, G. (2016): Prevalence of Intestinal Parasites and Associated Risk Factors Among Schoolchildren of Homesha District (Woreda) in Benishangul-Gumuz Regional State, Western Ethiopia. *J Fam Med Health Care*, 2(4): 57 – 64. DOI: 10.11648/j.jfmhc.20160204.16

Hailegebriel, T. (2017): Prevalence of intestinal parasitic infections and associated risk factors among students at Dona Berber primary school, Bahir Dar, Ethiopia. *BMC Infect Dis*, 17(1): 362. DOI: 10.1186/s12879-017-2466-x

Harhay, M.O., Horton, J., Olliaro, P.L. (2010): Epidemiology and control of human gastrointestinal parasites in children. *Expert Rev Anti Infect Ther*, 8(2): 219 – 234. DOI: 10.1586/eri.09.119

Hotez, P.J., Alvarado, M., Basáñez, M.G., Bolliger, I., Bourne, R., Boussinesq, M., Brooker, S.J., Brown, A.S., Buckle, G., Budke, C.M., Carabin, H., Coffeng, L.E., Fèvre, E.M., Fürst, T., Halasa, Y.A., Jasrasaria, R., Johns, N.E., Keiser, J., King, C.H., … Naghavi, M. (2014): The Global Burden of Disease Study 2010: Interpretation and Implications for the Neglected Tropical Diseases. *PLoS Negl Trop Dis*, 8(7): e2865. DOI: 10.1371/journal.pntd.0002865

Kumar, M.R., Doddamani, P.K., Parandekar, P., Kumar, P. (2019): Prevalence of Intestinal Parasitic Infections at a Tertiary Care Hospital: a Retrospective Study. *Int J Curr Microbiol App Sci*,8(6): 2822 – 2827. DOI: https://doi.org/10.20546/ijcmas.2019.806.340

Mahdy, A., Lim, Y., Surin, J., Wan, K., Hesham, A. (2008): Risk factors for endemic giardiasis: highlighting the possible association of contaminated water and food. *Trans R Soc Trop Med Hyg*, 102(5): 465 – 470. DOI: 10.1016/j.trstmh.2008.02.004

Mascarini-Serra, L. (2011): Prevention of soil-transmitted helminth infection. *J Glob Infect Dis*, 3(2): 175 – 182. DOI: 10.4103/0974-777X.81696

MB, A. (2017): Intestinal Parasitic Infection and Body Mass Index among School Children in Oshodi Lagos Nigeria. *Adv Cytol Pathol*, 2(2): 44 – 49. DOI: 10.15406/acp.2017.02.00015

Patel, P.K., Khandekar, R. (2006): Intestinal parasitic infections among school children of the Dhahira Region of Oman. *Saudi Med J*, 27(5): 627 – 632

Pradhan, P., Bhandary, S., Shakya, P.R., Acharya, T., Shrestha, A. (2014): Prevalence of intestinal parasitic infections among public school children in a rural village of Kathmandu Valley. *Nepal Med Coll J*, 16(1): 50 – 53

Rabone, M., Wiethase, J.H., Allan, F., Gouvras, A.N., Pennance, T., Hamidou, A.A., Webster, B.L., Labbo, R., Emery, A.M., Garba, A.D., Rollinson, D. (2019): Freshwater snails of biomedical importance in the Niger River Valley: Evidence of temporal and spatial patterns in abundance, distribution and infection with *Schistosoma* spp. *Parasit Vectors*, 12(1): 498. DOI: 10.1186/s13071-019-3745-8

Raja'a, Y.A., Sulaiman, S.M., Mubarak, J.S., El-Bakri, M.M., Al-Adimi, W.H., El-Nabihi, M.T., El-Dhobri, M.A., Raja'a, J.A. (2001): Some aspects in the control of schistosomosis and soil-transmitted helminthosis in Yemeni children. *Saudi Med J*, 22(5): 428 – 432

Sady, H., Al-Mekhlafi, H.M., Mahdy, M.A.K., Lim, Y.A.L., Mahmud, R., Surin, J. (2013): Prevalence 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

Singh Khadka, K., Prasad Kaphle, H., Gurung, K., Shah, Y., Sigdel, M. (2019): Study of Intestinal Parasitosis among School Going

Children in Pokhara, Nepal. *J Health Allied Sci*, 3(1): 47 – 50. DOI: 10.37107/jhas.54
Sitotaw, B., Shiferaw, W. (2020): Prevalence of Intestinal Parasitic Infections and Associated Risk Factors among the First-Cycle Primary Schoolchildren in Sasiga District, Southwest Ethiopia. *J Parasitol Res*, 2020: 8681247. DOI: 10.1155/2020/8681247
Sitotaw, B., Mekuriaw, H., Damtie, D. (2019): Prevalence of intestinal parasitic infections and associated risk factors among Jawi primary school children, Jawi town, north-west Ethiopia. *BMC Infect Dis*, 19(1): 341. DOI: 10.1186/s12879-019-3971-x
Williams, J.E. (2000): District laboratory practice in tropical countries. Part 1. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 94(2). DOI: 10.1016/s0035-9203(00)90297-9
Yaoyu, F., Xiao, L. (2011): Zoonotic potential and molecular epidemiology of *Giardia* species and giardiasis. *Clin Microbiol Rev*, 24(1): 110 – 140 DOI: 10.1128/CMR.00033-10