



Prevalence and Risk Factors for Intestinal Parasitosis among Internally Displaced Yemeni Children in Sana'a City

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Abstract

Objective: This study was conducted as preliminary research to determine the prevalence and risk factors for intestinal parasitosis (IP) among internally displaced Yemeni children (IDYC) in Sana'a city.

Methods: Using a cross-sectional study, a total of 400 children, 210 (52.5%) males and 190 (47.5%) females, aged 1-12 years, with a mean age of 7.9 ± 2.8 years, were recruited from five displaced camps of Sana'a city. Relevant data were enrolled by means of a questionnaire. Single fecal specimens were collected, processed, and examined by direct "saline & iodine," formol-ether concentration, and modified Ziehl-Neelsen staining techniques for detecting IP.

Results: The overall prevalence of IP was found to be 63.8% (255/400). Infection with protozoa was higher than helminths (42.8% vs. 26.3%, respectively). *G. lamblia* was the most frequently detected protozoan (18.5%), followed by *E. histolytica/dispar* (16.2%), whereas the coccidia of *Cryptosporidium spp.* and *C. belli* were the lowest (6.8% and 1.2% respectively). *A. lumbricoides* ranked the first helminth (11.2%), followed by *H. nana* (7.8%), while the Hookworm was the lowest (0.3%). Age group of 6-12 years old (AOR=2.7; $P=0.003$), behavioral factors related to not washing hands before meals (AOR=2.0; $P=0.043$) and not trimming nails (AOR=2.5; $P=0.017$) were risk factors "independent predictors" for IP among displaced children.

Conclusion: It can be concluded that the prevalence of IP among internally displaced Yemeni children in Sana'a city is substantial. This was mainly due to protozoa. Age-related demographics and behavioral factors concerning handwashing and nail trimming were the independent-significant risk factors for IP among displaced children.

Keywords: Intestinal Parasitosis; Prevalence; Risk Factors; Displaced Children; Sana'a

1. Introduction

Intestinal parasites are organisms that can infect the gastrointestinal tract (GIT) of humans and other animals [1]. Such parasites belong to two main groups: protozoa and helminths. Protozoa prevalently include *Entamoeba histolytica*, *Giardia lamblia*, and *Cryptosporidium parvum*, and helminths mainly involve *Hymenolepis nana*, *Enterobius vermicularis*, *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm species, and *Schistosoma mansoni* [1,2]. Humans get infected with these parasites through autoinfection, ingestion of food, drinking of water contaminated with cysts, oocysts, eggs, and/or penetration of skin by infective larvae [3]. Intestinal parasitosis (IP) represents a global health problem, particularly among children in developing countries, leading to morbidity and mortality [4]. IP creates a variety of symptoms in those affected, most of which manifest themselves in general weakness and GIT manifestations. These symptoms comprise abdominal pain, nausea, diarrhea, dysentery, and skin irritation around the anus and vulva [5]. Complications of IP negatively affect nutritional status, including decreased absorption of micronutrients and intestinal blood loss that can often lead to anemia,

besides lack of appetite, weight loss, and delayed growth consequences. It may also cause physical and mental disabilities [6]. The infection rate is the highest among children living in the poorest communities of developing nations [7,8]. Yemen is one of the poorest countries in the world. The current war, which began in March 2015, has also exacerbated the situation; 21.6 million Yemenis (two-thirds of the population) are estimated to be under the national poverty line and are dependent on humanitarian assistance. Years of devastating and unrelenting conflict have led to a protection and displacement crisis: more than 4.5 million people have been internally displaced [9]. These people were displaced from their native homes to live in other safe areas like Sana'a city. Internally displaced persons (IDPs) camps become the main shelter for those people [7,10,11]. As a result of poor hygienic conditions and lack of proper sanitation in the camps, many IDPs, particularly children, have become victims of infections, mainly with intestinal parasites [10]. The rate of IP among IDPs could be attributed to a lack of potable water supply and low levels of sanitation and socioeconomic status [11]. The prevalence rate of IP varies considerably from one area to the other according to various risk factors that include sociodemographic, behavioral, and

environmental [12,13]. The profile of IP among Yemeni people has been reported [14]. However, few researchers have dealt with the category of children in Sana'a, and they are missing studies on such a problem and its factors among displaced ones. The objective of this study was to assess the prevalence and risk factors for intestinal parasitosis among internally displaced Yemeni children in Sana'a city.

2. Subjects and Methods

2.1 Study Area, Design, and Population

This study was carried out at Sana'a city, which is made into a separate placement of its own called Amanat Al-Asimah. The city is the capital of Yemen, at an altitude of 2,200 m above sea level and located in the northern part of the country. It covers a surface area of 5,552 km² with a population of more than three million [15]. It is administratively divided into ten districts. The study was conducted in five selected districts hosting IDP camps. A cross-sectional study was conducted during October 2020 through October 2021 among 400 IDYC, 210 (52.5%) males and 190 (47.5%) females, aged 1 to 12 years (mean age 7.9 ± 2.84 years), selected randomly from the five districts as the study population. A pre-designed questionnaire administered via face-to-face interview was given to each child or guardian to collect data on the following factors: demographic (age and gender); socio-economic (parents' education status and family size); behavioral (handwashing before meals, handwashing after defecation, wearing shoes on soil, and nail hygiene); and environmental (drinking-water source and sanitation facilities). Data on nail hygiene, either trimmed or non-trimmed, were collected by direct observation. Inclusion criteria were subjects of both genders, aged 1–12 years, residents of the five districts, displaced for six months or longer, and guardian consent. Exclusion criteria were subjects older than 12 years; recent or current anti-parasitic medication; guardian refusal; or guardian unable to confirm age.

2.2 Sample Size and Sampling Method

2.2.1 Sample Size

The required sample size was estimated using a single population proportion standard formula Epi Info software, version 6 (Centers for Disease Control and Prevention, USA), and as per:

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

where (n) represents the sample size, (z) is the z-score corresponding to the desired confidence level, (d) is the acceptable margin of error (absolute precision), and (p) is the expected prevalence of infection.

The prevalence (p) of IP among internally displaced Yemeni persons was not known, wherefore the p rate was taken to be 50% (0.5). Besides, a 95% confidence interval (z), equivalent to 1.96, and a 5% (0.05) margin of error (d) were used. Therefore: $n = (1.96)^2 \cdot 0.5 \cdot (1-0.5) / 0.05^2$. This would minimally give a sample size of 384. With an additional 5% as a potential contingency or as non-responses, the total sample size required was 403. The response rate of children was about 95% of the minimum sample size. In this context, the sample size that could be achieved was four hundred (400), 210 males and 190 females.

2.2.2 Sampling Method

Districts hosting displaced camps are dispersed in Sana'a city. So, a cluster sampling method was followed. It is a multi-stage cluster sampling method that was completed in two stages. 1st stage was the random selection of districts, where five districts were chosen as clusters. 2nd stage was random selection of a limited number of displaced children within each district's camp using a simple random sampling whereby a sampling frame was prepared from the subjects' males & females' enrollment list in each camp, then children were chosen randomly by the lottery method.

2.3 Stool Collection and Examination

Prior to the collection of samples, basic instructions on collection were primarily given and clarified to guardians and children so that every child could place their specimen immediately and directly into the specified cup. Fresh single fecal sample of 5 g was collected from every child in a sterile, labeled, plastic-covered cup, including: "name, number, date of collection, and district's location". All samples were betimes transported to the lab of the Parasitology Department, Faculty of Medicine and Health Sciences, University of Sana'a. Each sample was preserved in 10% formalin, then processed and examined by the following methods of direct wet preparation, using saline and iodine, formol-ether sedimentation, and modified Ziehl-Neelsen stain for diagnosing IP, including coccidian protozoa.

2.4 Wet Mount Method

A drop of normal saline was placed on a clean slide, and a drop of iodine was added too. A small amount of material was taken from the interior and surface of each stool sample. The sample was mixed with saline and iodine using an applicator stick until a suitable thickness of wet mount smear preparation was achieved, whereby a good microscopic contrast and picture were obtained. The smear was then rapidly covered with a coverslip to avert dryness during the time of microscopic examination. The entire smear zone was systematically inspected using the microscopic low-power magnification of the objective 10X and then using the high magnification of the objective 40X. Using 40X, various microscopical fields for each smear were examined prior to deciding the sample as a negative [16].

2.5 Formol-Ether Sedimentation Method

A small part of each fecal sample was taken into a centrifuge tube of 15mL capacity and mixed with 7 mL of 10% formalin-water solution. The sample was sieved through two layers of medical gauze into a wide beaker, and the sieved liquid was poured into a centrifuge tube, and 3mL of ether was added. The sample tube was stoppered, shaken vigorously, and then centrifuged at 1500 rpm for three minutes. Four layers were formed. In ascending order, the layers consisted of a small amount of sediment at the bottom, a layer of formol-water, a plug of fecal debris, and a layer of ether at the top. The plug of debris was separated by moving an applicator stick, and the supernatant was discarded. The sediment was resuspended, and one drop was placed on a clean slide and examined microscopically using the 10X and 40X objectives [16, 17].

2.6 Modified Ziehl-Neelsen Staining Technique

After concentration of fecal specimens in the formol-ether method, a thin smear was prepared from one drop of each fecal sample sediment, and it was fixed in absolute methanol for three minutes. Smear was stained with cold carbol fuchsin for 15 minutes; then the stain was rinsed off in tap water. The smear was decolorized using 3% HCl in 95% ethanol until no more color flooded from the smear. The decolorizer was rinsed off in clean tap water. The smear was counterstained with 0.3% methylene blue for about 30 seconds. The counter stain was rinsed off in tap water and then blotted dry. The smear was examined microscopically using 40X and oil immersion (100X) objectives to identify the oocysts of intestinal coccidian parasites [16]. All samples were examined microscopically for cysts and oocysts of protozoa, and also for eggs and larvae of helminths under a light microscope. Samples were considered positive if cysts, oocysts or eggs and/or larvae were detected by any of the parasitological methods used.

2.7 Statistical Data Analysis

Data was primarily checked for consistency, coded and entered into the computer, and validation was made in Microsoft Excel spreadsheets. The data were then exported to the SPSS version 20.0 program for analysis. In univariate analysis, categorical variables were phrased and expressed in a descriptive pattern as frequencies, whereas continuous variables were expressed in arithmetic mean and standard deviation, and prevalence for IP was listed. Pearson's Chi-square was used to explore the possible association between categorical variables. Odds ratio (OR) was used to explore the potential association between exposure to different independent variables (factors) and the outcome/dependent variable (IP). Bivariate analysis was used to assess the association between each factor and IP. Such a test was basically used to estimate unadjusted "Crude odds ratio (COR or OR)" together with its corresponding 95% CI. Variable(s) showing a statistically significant P-value less than five (<0.05) were entered into a multivariable analysis model. This model was used to identify factors associated with IP. Besides, adjusted odds ratio (AOR) together with its corresponding 95% CI were used to assess the strength of associations. The cutoff value for statistical significance was considered at P-value <0.05.

2.8 Ethical Consideration

Ethical approval was obtained from the Ethical Committee in the Faculty of Medicine and Health Science, Sana'a University. An authorization letter for conducting the study was obtained from the health office of Amanat Al-Asimah, Sana'a. The goal of the work was explained to children and their parents, and informed consent was taken from every.

3. Results

The results showed that 255 displaced children were infected with at least one intestinal parasite, which constituted an overall prevalence of

63.8%. Infections with protozoa were more prevalent (42.8%) than helminths (26.3%) (Table 1 and Figure 1).

Table 1: Prevalence of intestinal parasitosis "including protozoa and helminths" among internally displaced Yemeni children in Sana'a City

Parasitic group	Intestinal Parasitosis	
	No.*	%
Protozoa	171	42.8
Helminths	105	26.3
Total	255**	63.8

*No.: number of infected children; %: percentage of infected children.

**Some children were infected with more than one parasite.

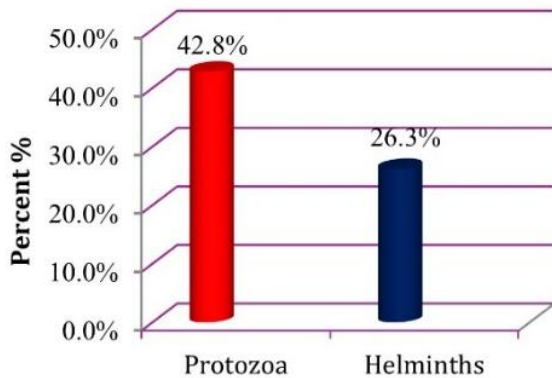


Figure 1: Percentage of infection with protozoa and helminths among internally displaced Yemeni children in Sana'a City (N = 400)

The highest percentage of infection with intestinal protozoa was for *G. lamblia* (18.5%), followed by *E. histolytica/dispar* (16.2%). Infection with *Cryptosporidium species* and *C. belli* represented the lowest percentages (6.8% and 1.2% respectively). The highest percentage of infection with helminths was for *A. lumbricoides* (11.2%), followed by *H. nana* (7.8%). Infection with *S. mansoni*, *E. vermicularis*, *T. trichiura*, *Taenia species*, and Hookworm represented the lowest percentages (2.5%, 1.8%, 1.5%, 1.2%, and 0.3% respectively) (Table 2).

Table 2: Distribution of intestinal parasitosis among internally displaced Yemeni children in Sana'a City according to parasite type

Type of parasite	No.	%
Protozoa*		
<i>Giardia lamblia</i>	74	18.5
<i>Entamoeba histolytica/dispar</i>	65	16.2
<i>Cryptosporidium species</i>	27	6.8
<i>Cystoisospora belli</i>	5	1.2
Helminths*		
<i>Ascaris lumbricoides</i>	45	11.2
<i>Hymenolepis nana</i>	31	7.8
<i>Schistosoma mansoni</i>	10	2.5
<i>Enterobius vermicularis</i>	7	1.8
<i>Trichuris trichiura</i>	6	1.5
<i>Taenia species</i>	5	1.2
Hookworm	1	0.3

No.: number of infected children; %: percentage of infected children; *E. coli* was detected in 56(14.0%) of children; *Some children had been infected with more than one parasite.

Children who harbored one parasite 'single infection' accounted for the majority of infected children 240 (94.1%), and 9 (3.5%) were infected with two parasites 'double infection'; however, those who infected with three parasites 'triple infection' represented a minority of them 6 (2.4%) (Table 3).

Table 3: Multiplicity of intestinal parasitosis among internally displaced Yemeni children in Sana'a City

Infection multiplicity	No.	(%)
One parasite*	240	94.1
Two parasites**	9	3.5
Three parasites***	6	2.4
Total	255	100%

*Single infections: *G. lamblia* 25.5%, *E. histolytica/dispar* 24.7%, *A. lumbricoides* 16.5%, *H. nana* 11.4%, *Cryptosporidium spp.* 7.8%, *E. vermicularis* 2.7%, *S. mansoni* 2.4%, *T. trichiura* 1.6%, *Taenia spp.* 1.2%, *C. belli* 0.3%.
 Double infections included: *G. lamblia* + *H. nana*, *G. lamblia* + *T. trichiura*, *Cryptosporidium spp.* + *S. mansoni* (each 0.8%); *E. histolytica/dispar* + *S. mansoni*, *Cryptosporidium* + *C. belli*, *S. mansoni* + *Taenia spp.* (each 0.4%).
 *Triple infections: *G. lamblia* + *Cryptosporidium spp.* + *C. belli* (0.8%), *G. lamblia* + *Cryptosporidium spp.* + *A. lumbricoides* (0.4%), *G. lamblia* + *E. histolytica/dispar* + *A. lumbricoides* (0.4%), *G. lamblia* + *A. lumbricoides* + *Taenia spp.* (0.4%), *Cryptosporidium spp.* + *C. belli* + *A. lumbricoides* (0.4%).

The rate of IP among males was slightly higher than that among females (65.7% vs. 61.6% respectively), and the difference between both genders and IP was not statistically significant. Concerning age, the age of children ranged between one and twelve (1 and 12) years. A higher rate of IP was found among children aged 6–12 years (74.7%) than those aged 1–< 6 years (22.6%). The risk of infection was higher in the older group, and the association was statistically significant (OR = 3.3, 95% CI: 1.7 – 6.8; P = 0.001). The percentage of infection was somewhat higher among children whose mothers were non-educated (65.9%) than those whose mothers were educated (59.7%). The association between the mother's education status and IP was not statistically significant (P=0.132). Though in the father's education status, the proportions of infection among children whose fathers were non-educated and educated were convergent (66.7% & 62.2% respectively). Also for family size and crowding index, the rates of infection among children belonged to > 5 group 'more than five family members living in each tent' and those who belonged to ≤ 5 group 'less than or equal to five family members living in each tent' were convergent (65.1% & 59.8% respectively) (Table 4).

Table 4: Association of socio-demographic factors with intestinal parasitosis among internally displaced Yemeni children in Sana'a City (N = 400)

Variable	No.	IP		P-value
		n	(%)	
Gender:				
Females	190	117	(61.6)	0.225
Males	210	138	(65.7)	
Age (years)				
1- < 6	84	19	(22.6)	0.001*
6-12	316	236	(74.7)	
Mother's education status				
Educated#	139	83	(59.7)	0.132
Non educated‡	261	172	(65.9)	
Father's education status				
Educated#	259	161	(62.2)	0.216
Non educated‡	141	94	(66.7)	
Family size*				
≤5 members	102	61	(59.8)	0.200
>5 members	298	194	(65.1)	

No. : number of examined; n: number of infected; IP: intestinal parasitosis; #Educated: primary, secondary or university; ‡Non educated: illiterate or just read and write; *Crowding index: a high crowding index was estimated as per the family size and for (> 5 members group) in which more than five family members living in each tent with an approximate size of 4x4 meters.

Infection percentage among children who did not practice handwashing "washing hands" before meals was higher than among those who did (92.4% vs. 36.3% respectively). The association between washing or not washing hands before meals and IP was statistically significant (OR = 2.6, 95% CI: 1.3–4.9; P = 0.010). For washing hands after defecation, the percentage of infection among children who did not practice handwashing "washing hands" after defecation was insignificantly higher than among those who did (73.3% vs. 63.0% respectively; P = 0.175). It was actually

observed that children who had non-trimmed nails were at a higher risk rate of infection than those who had trimmed nails (87.7% vs. 29.3% respectively). The association between nail hygienic status of non-trimmed nails, "non-trimming nails," and IP was statistically significant (OR = 3.1, 95% CI: 1.5 - 6.2; P = 0.001). About wearing shoes when walking on the ground soil or outside, children who did not practice wearing shoes had an insignificantly higher infection rate than those who did (67.2% vs. 60.8% respectively; P = 0.111). children who used unfiltered water as a source of drinking had an insignificant higher percentage of infection than those who used filtered water (64.6% vs. 54.5% respectively; P = 0.168). Infection percentage among subjects who used the unsanitary system was relatively higher than those who used the sanitary system (74.2% vs. 62.9%, respectively), in spite of non-statistically significant association (P = 0.143) (Table 5).

Table 5: Association of behavioral and environmental factors with intestinal parasitosis among internally displaced Yemeni children in Sana'a City (N = 400)

Variable	No.	IP		P-value
		n (%)		
Washing hands before meals:				
Yes	204	74(36.3)		0.010*
No	196	181(92.4)		
Nails hygienic status:				
Trimmed	164	48(29.3)		0.001*
Non trimmed	236	207(87.7)		
Wearing shoes when walking on the ground soil or outside:				
Yes	217	132(60.8)		0.111
No	183	123(67.2)		
Source of drinking water:				
Filtered water	33	18(54.5)		0.168
Unfiltered water	367	237(64.6)		
Sewage disposal system:				
Sanitary	369	232(62.9)		0.143
Unsanitary	31	23(74.2)		

Bivariate analysis was conducted for all variables. It was basically used to test, explore, and predict the association of each independent categorical variable with IP. Three variables, "factors (or predictors)," were statistically associated with infection. That indicated, the prevalence of IP or risk of infection among children increased with 2.6 to 3.3 times due to the association of the following: age group of 6–12 years old (OR = 3.3, 95% CI: 1.7–6.8; P = 0.001), not washing hands before meals (OR = 2.6, 95% CI: 1.3 - 4.9; P=0.010) and not trimming nails (OR = 3.1, 95% CI: 1.5 - 6.2; P = 0.001) (Table 6).

A multivariable analysis was used to adjust and identify the most significant risk factors or independent predictors associated with IP. After adjustment, it was confirmed that, age group of 6–12 years old (AOR = 2.7, 95% CI: 1.4 - 5.2; P = 0.003); not washing hands before meals (AOR=2.0, 95% CI: 1.1 - 3.5; P = 0.043) and not trimming nails (AOR = 2.5, 95 % CI: 1.2–4.4; P=0.017) were the independent predictors that statistically associated with infection (Table 7).

4. Discussion

Results of the current study were discussed with reference to the existing literature as much as possible; the required literature was cited to present either a convergence or a divergence in view of the explanation and interpretation of these results. In general, the results have been discussed with much support from the literature. Eventually, the inferences emerging from the discussion were also presented [18].

The findings of the present study indicated that the prevalence of IP was high and can be considered a health problem. Such inference was evident from Table 1, wherein the overall prevalence of pathogenic IP among internally displaced Yemeni children in Sana'a city was 63.8%. A nearly similar rate (63.0%) was reported from a previous study conducted among displaced subjects in Sudan [13]. This is somewhat consistent with another study carried out in Pakistan (65.3%) [7]. A high prevalence rate of IP in this study could be attributed to many factors including: environmental faecal contamination, poverty, poor quality of life and poor personal hygiene of children as well as lack of safe water supply, illiteracy and overcrowding, all of the above-mentioned factors were behind the

high rate of IP [7,13]. Further, a much higher rate of 79.5% was reported from Nigeria [11]. In contrast, lower prevalence rates of 17.0%, 21.8%, and 20.6% were documented from Sudan [19], Nigeria [20], and Italy [21], respectively. A much lower rate of 5.8% was reported from Iraq [22]. The rates of IP may have differed according to multiple factors: type of study, hospital or community-based, demographic, socioeconomic, sanitary, and environmental conditions. On top of that, the parasitological techniques applied in each study could affect the results [23].

Table 6: Bivariate analysis of factors associated with intestinal parasitosis among internally displaced Yemeni children in Sana'a City (N = 400)

Variable	No.	IP		OR (95% CI)	P-value
		n (%)			
Gender:					
Females	190	117(61.6)		R	0.225
Males	210	138(65.7)			
Age (years):					
1 - < 6	84	19 (22.6)		R	0.001*
6 - 12	316	236 (74.7)		3.3(1.7-6.8)	
Mother's education status:					
Educated	139	83(59.7)		R	0.132
Non educated	261	172(65.9)		1.3(0.9-2.0)	
Father's education status:					
Educated	259	161(62.2)		R	0.216
Non educated	141	94(66.7)		1.2(0.8-1.9)	
Family size*:					
≤5 members	102	61(59.8)		R	0.200
>5 members	298	194(65.1)		1.3(0.8-2.0)	
Washing hands before meals:					
Yes	204	74(36.3)		R	0.010*
No	196	181(92.4)		2.6(1.3-4.9)	
Washing hands after defecation:					
Yes	370	233(63.0)		R	0.175
No	30	22(73.3)		1.6(0.7-3.7)	
Nails hygienic status:					
Trimmed	164	48(29.3)		R	0.001*
Non trimmed	236	207(87.7)		3.1(1.5-6.2)	
Wearing shoes when walking in the ground soil:					
Yes	217	132(60.8)		R	0.111
No	183	123(67.2)		1.3(0.9-2.0)	
Source of drinking water:					
Filtered water	33	18(54.5)		R	0.168
Unfiltered water	367	237(64.6)		1.5(0.7-3.1)	
Sewage disposal system:					
Sanitary	369	232(62.9)		R	0.143
Unsanitary	31	23(74.2)		1.7(0.7-3.9)	

No.: number of examined; n: number of infected; IP: intestinal parasitosis; non trimmed nails as a hygienic status was considered as one behavior of this study and it was named "not trimming nails"; OR: odds ratio; CI: confidence interval; R: reference category; *significant association (P < 0.05).

Table 7: Multivariable analysis of factors associated with intestinal parasitosis among internally displaced Yemeni children in Sana'a City (N = 400)

Variable	IP		
	AOR	95% CI	P-value
Age group of 6–12 years old	2.7	1.4-5.2	0.003*
Not washing hands before meals	2.0	1.1-3.5	0.043*
Not trimming nails	2.5	1.2-4.4	0.017*

IP: intestinal parasitosis; non-trimmed nails as a hygienic status was considered as one behavior of this study, and it was named "not trimming nails"; AOR: adjusted odds ratio; CI: confidence interval; *significant association (P < 0.05).

In the present study, intestinal protozoa were more prevalent than helminths (42.8% vs. 26.3%, respectively). Intestinal protozoan parasites are considered to be directly transmitted from one child to another via the faeco-oral route, contributing to the high rate of infection because of poor hygiene, close contact, and overcrowding. Infection with these protozoa occurs without the need for an external cycle or intermediate host. Discharge of infective cysts in stool results in environmental contamination, whereby such cysts are ingested by another host [13]. Nevertheless, helminths (excluding principally *Hymenolepis nana* and *Enterobius vermicularis*) are considered indirectly transmitted parasites.

These helminths require certain environmental conditions of soil, climate, intermediate host, and factors that would limit their spread [24]. The helminth passes its oval stage in the stool of an infected individual, and this stage needs an external cycle or growth period in an intermediate host or environment to be infective and transmitted to a susceptible person [25]. Immature eggs of STHs, such as *Ascaris lumbricoides*, *Trichuris trichiura*, and *Ancylostoma duodenale*, require proper environmental conditions, including temperature, humidity, shade, etc., to develop in soil either into infective eggs or larvae [24]. Also, the oval stage of *Schistosoma mansoni* necessitates a snail as an intermediate host to grow into an infective cercarial stage. For the above-mentioned clarification, the probability of infection with protozoa might be higher than with helminths [22].

As for the protozoa in the present results, *Giardia lamblia* was the most prevalent (18.5%), followed by *Entamoeba histolytica/dispar* (16.2%). A comparable order was reported from Sudan [13]. Anywise, infection percentages vary according to several factors. Socio-economic, sanitary and environmental conditions are among the most common contributing factors [13,10]. Consistent with the present findings, the rate of *G. lamblia* was reported from Iraq (17.5%) [22]. A higher rate of 59.8% was documented from Nigeria [26]. In contrast, lower rates of *G. lamblia* were reported from other studies: 1.1% in Nigeria [11] and 2.5% in Italy [21].

In the present study, *E. histolytica/dispar* was detected in 16.2%. This is in agreement or somewhat lower compared with 14.3% and 23.5% from Sudan and Nigeria respectively [11,13]. Further, much higher rates (69.9% and 67.9%) were recorded from Iraq and Nigeria respectively [22,26]. According to this study, infection with *E. histolytica/dispar* was high and it was the second intestinal parasite detected after *G. lamblia*. It is worth mentioning that prevalence estimates of *E. histolytica* are variable and that non-pathogenic strains—mainly *E. dispar*, and to a lesser extent *E. hartmanni*—could lead to overestimation of rates [27]. Identification of such strains may require more specific and sensitive methods and use of strain-specific immuno-molecular testing [28]. In contrast, a lower rate of *E. histolytica/dispar* (6.0%) was reported from Pakistan [7]. Moreover, much lower rates (0.4% and 1.7%) were documented from Sudan and Iraq respectively [19,29].

In the current findings, infection with the coccidian *Cryptosporidium* spp. was 6.8%. A much higher rate of 16.3% was reported from Iraq [30]. However, a later study in the same country revealed a lower rate of 1.4% [29]. *Cystoisospora belli* was another coccidian detected in this study, at 1.2%. A nearly similar rate (1.6%) was reported from Nigeria [26]. An extremely lower rate (0.1%) was recorded from Iraq [30]. According to this study, infections with *Cryptosporidium* spp. and *C. belli* represented the lowest percentages of protozoa detected. These protozoa have been documented as opportunistic parasites, more prevalent in immunocompromised individuals [31-33].

Concerning helminths in the present results, infection percentages for *A. lumbricoides*, *T. trichiura* and hookworm (STHs) were 11.2%, 1.5%, and 0.3%, respectively. In accordance with this study, 11.2% of children were infected with *A. lumbricoides*. Higher rates (18.0% and 19.7%) were reported from Pakistan and Nigeria respectively [7,11]. A much higher rate (34.2%) was documented from Nigeria [26]. Conversely, a lower rate of 5.5% was found in another previous study from Nigeria [20].

In our findings, *T. trichiura* was detected at 1.5%. This was supported by a study in Colombia, which reported 2.1% [10]. Much lower rates of 0.2%, 0.5% and 0.3% were documented from Sudan, Nigeria and Italy respectively [19-21]. On the other hand, a higher rate of 17.9% was reported from Nigeria [26]. In the present work, the rate of *T. trichiura* was relatively low compared to other studies. This may be attributable to climatic and/or hygienic practice differences [10,26].

Hookworm infection in the current results was detected in one case only (0.3%). A nearly similar rate (0.2%) was reported from Iraq. A slightly higher rate (1.6%) was recorded from Italy [21]. A higher rate of 6.1% was reported from Nigeria [11], and another Nigerian study reported 32.1% [26]. In this study, the rate of hookworm was the lowest; *Strongyloides stercoralis* larvae were absent, which was not unexpected since the Harada-Mori method was not used to detect hookworm or *S. stercoralis* larvae [10,29].

In current findings, infection rate with *Hymenolepis nana* was 7.8%. A comparable rate (5.3%) was reported from Sudan [13]. However, higher rates of 32.6% and 15.0% were documented from Nigeria and Pakistan respectively [20,7]. Moreover, an extremely high rate (95.7%) was reported from Sudan [36]. In contrast, lower rates of 0.6% and 1.7% were

presented from Colombia and Italy respectively [10,21]. *H. nana* is considered a directly transmitted parasite; in this study, the lifestyle of displaced children may explain this. Living in such conditions perhaps increases spread of this parasite [11,34].

No data about participants' original residence (urban or rural) was collected—among the study's limitations. The infection rate of *S. mansoni* was 2.5% among children who likely emigrated from rural areas. They probably acquired infection through swimming in canal or pond water infested with schistosome cercariae [35]. Lower rates (0.7% and 1.1%) were recorded from Sudan and Italy, respectively [13,21]. In contrast, a higher rate of 22.0% was reported from Nigeria [11].

Regarding *Taenia* species, high rates were reported from Sudan and Pakistan (2.9% and 9.0%) [36,7]. This disagrees with present findings, where *Taenia* species eggs were detected in five cases (1.2%). This low rate is consistent with a Nigerian study (1.1%) [11]. Lower rates of 0.6% and 0.9% were reported in Italy and Iraq respectively [21,22]. Tapeworm infection is transmitted by eating undercooked meat. Yemeni families usually cook food well, which may explain the low infection rate in this study [37]. For *E. vermicularis*, infection rate was clearly low. One limitation was not using Scotch tape to diagnose enterobiasis [10,22].

The results showed that 94.1% of infected children had one parasite; 3.5% had two; 2.4% had three. Previous studies show that multiplicity of parasitic infections in children depends on socioeconomic factors including education and income [38,10,25]. One Nigerian study reported 50.8% with single parasite infection, 29.5% double, and 18.2% triple infection; this mirrors low socioeconomic conditions [11].

The current study also assessed socio-demographic and behavioral factors associated with IP. Age group 6–12 years was an independent predictor of infection (AOR = 2.7) vs. 1–6 years ($p < 0.05$). The likelihood of infection increased with age, possibly due to more outdoor activity and poor hygiene practices—consistent with studies from Italy and Iran [38,25], but conflicting with reports from Sudan, Peru, and Ethiopia [19,39,40]. Conversely, lower infection rates in younger children may be due to limited mobility and exposure [38].

Behavioral factors: not washing hands before meals was a significant predictor (AOR = 2.0), supporting findings from previous studies [13,7]. Contaminated hands facilitate transmission of *G. lamblia*, *E. histolytica*, and *H. nana* [11]. However, inconsistent associations were found in other studies [36,11]. Washing hands after defecation showed no significant association—potentially due to self-reporting bias [41].

Not trimming nails was the second independent predictor (AOR = 2.5). Children with non-trimmed nails had 2.5 times higher infection risk than those with trimmed nails—consistent with a study from Ethiopia [40]. Fingernail hygiene is important since *G. lamblia*, *E. histolytica* cysts, and *H. nana* eggs can survive under nails [42]. This contradicts some studies reporting no significant association [10].

Some socio-demographic, behavioral, and environmental variables showed no association with IP—possibly due to limitations of the study design and self-report biases [41]. Data analysis models can identify associations but not causation [41]. These findings align with some studies from Ethiopia [40] and conflict with others from Sudan [36].

5. Limitations of the Study

The present work undoubtedly shares all the limitations of a cross-sectional study design. In this context, social-desirability bias was a potential for self-reported responses. In addition, the study research is based on secondary information from the internet, books, journals, and different websites. Contextually, there was a limitation in collecting and citing considerable references because previous displacement-based studies were very scarce, there was also a block in undertaking and examining direct wet mount in the camps, and a barrier in proceeding with scotch adhesive tape for correct and actual diagnosis of enterobiasis among children. Besides, there are a lot of challenges, especially resources and constraints, that obstacle of performing more specific and sensitive techniques for the real and exact pinpointing of IP rate.

6. Conclusion

It can be concluded that the prevalence of IP among internally displaced Yemeni children in Sana'a city is decisive and conclusive; age-related demographics and behavioral factors concerning handwashing and nails trimming were the independent-significant risk factors for IP among displaced children. This study is a primarily "timely primal" report on enteric parasites in internally displaced Yemeni children.

Data Availability

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

Ethical Approvals

This study was approved by the Institutional Review Board of the Ethics Committee at the Faculty of Medicine and Health Sciences, Sana'a University, Yemen (Approval No. REC-48-2021). All procedures were conducted in accordance with the ethical standards outlined in the Declaration of Helsinki.

Subject Consent

Verbal informed consent was obtained from the parents or legal guardians of all participating children after a full explanation of the study's purpose and procedures. Participation was voluntary, and consent was reaffirmed prior to data collection. All collected data were anonymized and used solely for research purposes.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

SAQ conceived the research idea, designed the study protocol, collected and analyzed the data, interpreted the findings, and drafted the manuscript. SAQ supervised the overall project.

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