

Intestinal Parasitic Infections among Displaced Children in Sudan amid Ongoing Armed Conflict: Prevalence and Associated Factors

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Research Article

Keywords: intestinal parasites, displaced children, Gezira State, Sudan

Posted Date: October 18th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11368079/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Intestinal parasitic infections remain an important public health problem among children, particularly in displaced populations where disruption of water supply, sanitation, hygiene, housing, and health services may increase exposure. This study aimed to determine the prevalence and distribution of intestinal parasites and associated risk factors among displaced children in Wadelfadni, Gezira State, Sudan.

Methods

A total of 300 school-aged, displaced children were included in this study. The supplied results contain demographic, risk factors, gastrointestinal symptoms, and parasitological variables. Single fresh stool specimens were collected and microscopically examined using three methods. Frequencies, percentages, and associations between variables were analyzed using SPSS.

Results

The mean age was 11.84 ± 3.26 years; 155 (51.7%) children were aged ≤ 12 years and 205 (68.3%) were male. Intestinal parasites were detected in 128/300 children, giving an overall prevalence of 42.7% (95% CI: 37.1%–48.3%). Mono-infection occurred in 120 (40.0%) children, and mixed infection in 8 (2.7%). *Giardia lamblia* was the most frequently reported parasite (65; 21.6%), followed by *Entamoeba histolytica/dispar* (24; 8.0%). *Hymenolepis nana* and *Schistosoma mansoni* were equal in their prevalence (20; 6.7%), *Enterobius vermicularis* (6; 2.0%), and *Taenia* spp. (3; 1.0%). Overall parasitic infection was significantly associated with age group ($P = 0.0001$) and family education ($P = 0.001$), while no significant association was reported with sex ($P = 0.399$) or water source ($P > 0.05$).

Conclusion

Intestinal parasitic infections were common among school-aged, displaced children in the study area, affecting more than two in five participants. *Giardia lamblia* predominated, and younger age was an important correlate of infection. The findings support integrated interventions emphasizing parasitological screening and treatment, safe water, sanitation, hygiene education, and focused protection of displaced children.

Key message

What is already known on this topic:

- The data on intestinal parasites infection among internally displaced school-age children from Sudan were limited.

What this study adds:

- This is the first study that was conducted among internally displaced school-age children in Sudan.
- Overall, intestinal parasite infection was found in 128 children, which represents 42.7% (95% CI: 37.1%–48.3%).
- Mono-infection was recorded in 120 (40.0%) children and mixed infection in 8 (2.7%).
- *Giardia lamblia* was the most frequent parasite detected in 65 (21.6%) children. *Entamoeba histolytica/dispar* was detected in 24 (8.0%), *Hymenolepis nana* in 20 (6.7%), *Schistosoma mansoni* in 20 (6.7%), *Enterobius vermicularis* in 6 (2.0%), and *Taenia* spp. in 3 (1.0%).
- A strong significant association was between children aged ≤ 12 years and family education, good hygiene of the fingernails and latrine utilization, and presence of intestinal parasite infection ($P = 0.0001$), each.
- Gastrointestinal symptoms and signs, including anorexia, nausea/vomiting, abdominal pain, bloating, and the presence of bloody stool, were strongly and significantly associated with the presence of intestinal parasite infection. ($P = 0.0001$), each.

How this study might affect research, practice, or policy:

- These results findings support integrated control measures for displaced communities, including accessible diagnosis and treatment, safe-water provision, sanitation, hygiene promotion, and targeted health education for children and food.

Introduction

Intestinal parasitic infections (IPIs) remain a major public health problem worldwide among school-age children, particularly in low-resource and conflict-affected settings (1, 2). These infections can cause intestinal inflammation, abdominal pain, diarrhea, malabsorption, nutrient deficiencies, and anemia, contributing to malnutrition and impaired physical growth (3–5). Chronic or heavy infections may also negatively affect cognitive development, concentration, and learning abilities, resulting in increased school absenteeism and reduced academic performance (6–8).

Intestinal parasites are primarily transmitted through the fecal–oral route, particularly by ingesting contaminated food or drinking water containing infective cysts, oocysts, eggs or skin penetration by infective larvae present in contaminated soil or water (9, 10). The common risk factors include contaminated hands, poor personal hygiene, direct contact with infected individuals, inadequate sanitation, open defecation, overcrowded living conditions, and limited access to safe water, all of which facilitate the transmission and spread of intestinal parasitic infections. (11, 12). The highest burden of intestinal parasitic infection occurs mainly in children in tropical and subtropical regions, particularly in

sub-Saharan Africa (13, 14). The prevalence rates are 23.6%, 23.95% in Nigeria (15, 16), 62.3%, 48% in Ethiopia (17, 18), 53.8%, 10.7–33% in Kenya (19, 20), 60% in Chad (21), 20.3% in Uganda (22), and 4.9% in Cameroon (23).

Sudan has historically experienced conditions favorable for the transmission of intestinal parasites, including marked disparities in access to safe drinking water, sanitation, healthcare, and diagnostic services (24, 25). The war in Sudan has forcibly displaced nearly 13 million people, both internally and to other countries (26). Internally displaced populations may be particularly vulnerable to intestinal diseases (27). In Sudan, the prevalence of intestinal parasites in children varies, with rates of 44% reported in police force camps in Khartoum (28), 28.4% for *Entamoeba histolytica* (*E. histolytica*), and 9.8% for *Giardia lamblia* (*G. lamblia*) in southern Sudan (29), 35.8% in Al-Kalakla, Khartoum State (30), 35.5% in Khartoum (31), 35.3% in Shendi Locality (32), and 33.9% in Kosti City (33).

Many studies have demonstrated that water sources, hygiene practice, parents' education, and the viability of latrines are linked to the prevalence of intestinal parasites among children (34–37). Some medically important parasites may cause anemia, nutritional deficiencies, and impaired physical and cognitive development, contributing to school absenteeism and poor academic performance (4, 38, 39). Therefore, determining the prevalence and associated risk factors of intestinal parasitic infections among displaced children is important for identifying vulnerable groups and guiding appropriate prevention and control interventions. This study aimed to determine the prevalence of intestinal parasitic infections and identify associated demographic, environmental, and clinical factors among school-aged, displaced children living in camps near Wadelfadni, Gezira State, Sudan.

Materials and Methods

Study design and setting

This cross-sectional study was conducted among internally displaced school-age children in the Wadelfadni area, Gezira State, Sudan, from 1 August to 30 September 2026. The displaced children were identified according to Mooney E. (40).

Study population and sample size

The required sample size for this study was calculated using the formula described by Charan and Biswas (41). This formula, $n = Z^2 \times P (1 - P) / d^2$, was applied

Where:

n = required sample size

Z = standard normal deviation at the 95% confidence level (1.96)

P = Expected prevalence based on the average of previous studies conducted among school-age children in Sudan, which were 35.3% (32), 33.9% (33), and 12.9% (42), with an average prevalence of 27.4%.

d = allowable margin of error (5%)

The sample size was calculated as follows:

$$n = (1.96)^2 \times 0.274 (1 - 0.274) / (0.05)^2$$

$$n = 3.8416 \times 0.274 \times 0.726 / 0.0025$$

$$n = 305.6 \sim = 306 \text{ children.}$$

The calculated sample size was 306; after adding a 10% non-response rate, the required sample size was 340 children. However, 300 displaced school-aged children provided stool samples and were included in the final analysis with an accepted response rate of 88.2%.

Data collection

The data recorded in the supplied results was collected using a predesigned structured questionnaire that was used in a previous study conducted among Sudanese schoolchildren but with some modifications (33). The questionnaire data included age, sex, family education, source of water, fingernail hygiene, latrine utilization, and gastrointestinal symptoms, including anorexia, nausea or vomiting, abdominal pain, bloating, and presence of bloody stool.

Stool collection and parasitological examination

Each participant was provided with a clean, dry, wide-mouthed, leak-proof, appropriately labeled stool container and instructed to provide a freshly passed stool specimen. Care was taken to avoid contamination of the specimen with urine, water, soil, or other materials.

The specimens were examined as soon as possible after collection macroscopically for blood and the presence of visible adult worms or worm segments. Three microscopic examinations were performed for each specimen, direct saline wet mounts, iodine wet mounts, and a sedimentation concentration technique. In direct saline microscopic examination, a small portion of fresh stool was placed on a clean glass slide and emulsified in one drop of 0.85% physiological saline to prepare a thin, uniform suspension, and a coverslip was gently applied. A Lugol's iodine solution was added to the second wet mount to facilitate visualization of protozoan cysts and their internal structures. The formalin-ethyl acetate sedimentation concentration technique was based on emulsifying stools with formalin in a conical centrifuge tube, then mixing and shaking. The suspension was sieved or strained into a beaker to remove the debris and large particles, then the suspension was transferred into a conical tube. The ether,

or ethyl acetate, was added to the suspension, then centrifuged. The supernatant was discarded, and the resulting sediment was transferred into a microscope slide with cover glass. Each of these preparations was examined systematically under a light microscope using the 10× objective for initial screening and the 40× objective for detailed identification (43). The specimens were examined for intestinal parasites, including protozoan trophozoites and cysts and helminth eggs and larvae. An *E. histolytica* was reported as *E. histolytica/dispar* because they are morphologically identical and cannot be reliably distinguished by microscopy. Other special techniques and stains, such as perianal adhesive tape for *Enterobius vermicularis* (*E. vermicularis*) or the modified acid-fast staining method for the detection of intestinal coccidian parasites, were not used.

Statistical analysis

Data was analyzed using IBM SPSS Statistics, version 23.0. Descriptive statistics were summarized as frequencies and percentages for categorical variables, while age was expressed as the mean $\pm$ standard deviation (SD). Associations between potential risk factors and intestinal parasitic infection were assessed using odds ratios (ORs) with 95% confidence intervals (CIs) and corresponding P values. A P value of < 0.05 was considered statistically significant.

Results

Among the 300 school-aged, displaced children, the mean age was 11.84 ± 3.26 years. Children aged ≤ 12 years accounted for 155 (51.7%) participants, while 145 (48.3%) were aged > 12 years. Males represented 205 (68.3%) participants and females 95 (31.7%). Regarding family education, 189 (63.0%) of them were educated. The well as a water source was the most common use (156; 52.0%), followed by a borehole (119; 39.7%). The fingernail hygiene practice was better in 175 (58.3%) of children, and 135 (45.0%) of them were reported to use a latrine (Table 1).

Table 1
General characteristics of studied children in
displaced camps near Wadelfadni, Gezira state,
Sudan (n = 300).

Item	Frequency (n)	Percent (%)
Age group (mean $\pm$ SD 11.84 $\pm$ 3.26 years)		
$\leq$ 12 years	155	51.7
> 12 years	145	48.3
Sex		
Male	205	68.3
Female	95	31.7
Family education		
educated	189	63.0
not educated	111	37.0
Source of water		
Borehole	119	39.7
Well	156	52.0
Both	25	8.3
Good hygiene of the fingernails		
Yes	175	58.3
No	125	41.7
Latrine utilization		
Yes	135	45.0
No	165	55.0
Anorexia		
Yes	57	19.0
No	243	81.0
Nausea or vomiting		
Yes	68	22.7
No	232	77.3
Abdominal pain		

Item	Frequency (n)	Percent (%)
Yes	73	24.3
No	227	75.7
Bloating		
Yes	65	21.7
No	235	78.3
Blood in stool		
Yes	32	10.7
No	268	89.3

Intestinal parasites were detected in 128 of 300 children, corresponding to an overall prevalence of 42.7% (95% CI: 37.1%–48.3%); 172 (57.3%) were reported as uninfected (Fig. 1). Mono-infection was recorded in 120 (40.0%) children and mixed infection in 8 (2.7%). *G. lamblia* was the most frequent parasite detected in 65 (21.6%) children. *E. histolytica/dispar* was detected in 24 (8.0%), *H. nana* in 20 (6.7%), *S. mansoni* in 20 (6.7%), *E. vermicularis* in 6 (2.0%), and *Taenia* spp. in 3 (1.0%) (Table 2).

Table 2
Prevalence of intestinal parasites school age displaced children in displaced camps near Wadelfadni, Gezira state, Sudan (n = 300).

Item	Frequency (n)	Percent (%)
protozoa		
<i>G. lamblia</i>	65	21.6
<i>E. histolytica/ dispar</i>	24	8.0
Helminth		
<i>H. nana</i>	20	6.7
<i>S. mansoni</i>	20	6.7
<i>E. vermicularis</i>	6	2.0
<i>Taenia</i> spp.	3	1.0
Number of parasites		
Non infected	172	57.3
Mon-infection	120	40.0
Mixed infection	8	2.7

Infection was more frequent among children aged ≤ 12 years (83/155; 53.5%) than among those aged > 12 years (45/145; 31.0%), and the association with age was statistically significant ($P = 0.0001$). No statistically significant association with sex was reported: 89/205 (43.4%) males and 39/95 (41.1%) females were infected ($P = 0.399$). Children from families classified as not educated had a higher reported prevalence (72/111; 64.9%) than those from educated families (56/189; 29.6%), with a significant association (OR 4.385, 95% CI 2.661–7.224; $P < 0.0001$). Infection prevalence was slightly similar across borehole, well, and combined water sources, and no significant association between infection and water source was reported ($P > 0.05$). The supplied result also reports significant associations for fingernail hygiene and latrine utilization and parasitic infection ($P < 0.0001$), each. (Table 3).

Table 3
Socio-demographic characteristics and hygienic risk factors of parasitic infection in displaced camps near Wadelfadni, Gezira state, Sudan (n = 300).

Item	Presence Intestinal parasites		OR (95% CI)	P value
	Yes n (%)	No, n (%)		
Age group				
≤ 12 years	83 (53.5%)	72 (46.5%)	0.40 (0.243–0.626)	0.0001
> 12 years	45(31.0%)	100 (69.0%)		
Sex				
Male	89(43.4%)	116(56.6%)	1.10(0.673–01.804)	0.399
Female	39(41.1%)	56(58.9%)		
Family education				
Educated	56(29.6%)	133(70.4%)	4.385(2.661–7.224)	0.0001
Not educated	72(64.9%)	39(35.1%)		
Source of water				
Borehole	48(40.3%)	71(59.7%)	1.172(0.733–1.873)	0.294
Well	69(44.2%)	87(55.8%)	1.14(0.722–1.807)	0.325
Both	11(44.0%)	14(56.0%)	1.06(0.465–2.42)	0.524
Good hygiene of the fingernails				
Yes	41(23.4%)	134(76.6%)	0.134(0.080–0.224)	0.0001
No	87(69.6%)	38(30.4%)		
Latrine utilization				
Yes	51(30.9%)	114(69.1%)	0.289(0.177–0.471)	0.0001
No	36(26.7%)	99(73.3%)		

P < 0.05 was considered statistically significant.

The supplied descriptive table reported anorexia in 56 (98.2%) children, nausea /or vomiting in 68 (100%), abdominal pain in 73 (100%), bloating in 64 (98.5%), and bloody stool in 31 (96.6%). The symptom-by-infection reported statistically significant associations for all listed symptoms (P < 0.0001), each in Table 4.

Table 4
Prevalence of gastrointestinal symptoms and signs
in displaced camps near Wadelfadni, Gezira state,
Sudan (n = 300).

Item	Presence Intestinal parasites		P value
	Yes n (%)	No, n (%)	
Anorexia			
Yes	56(98.2%)	1(1.8%)	0.0001
No	72(29.6%)	171(70.4%)	
Nausea or vomiting			
Yes	68(100.0%)	0(0%)	0.0001
No	60(25.9%)	172(74.1%)	
Abdominal pain			
Yes	73(100.0%)	0(0%)	0.0001
No	55(24.2%)	172(75.8%)	
Bloating			
Yes	64(98.5%)	1(1.5%)	0.0001
No	64(27.2%)	171(72.8%)	
Bloody stool			
Yes	31(96.9%)	1(3.1%)	0.0001
No	97(36.2%)	171(63.8%)	

P < 0.05 was considered statistically significant.

Discussion

The present study demonstrates a substantial burden of IPIs among school-aged, displaced children living in camps near Wadelfadni, Gezira State, Sudan. An overall prevalence was 42.7% (95% CI: 37.1%–48.3%), which was similar to the study conducted in camps of the police force in Khartoum, Sudan, that revealed that 44% of children had IPIs (28). Our findings were higher than previous studies conducted in Sudan from Kosti (33.9%) (33), Shendi (35.3%) (32), Khartoum Hospital (35.5%) (31), and Al-Kalakla, Khartoum State (35.8%) (30). It was also higher than the prevalence of 32.9% reported by Ahmed and Abu-Sheishaa among schoolchildren in Dakahlia Governorate, Egypt (44). A substantially lower prevalence of IPIs was reported in Nigeria (23.6% and 23.95%, respectively) (15, 16), Uganda (20.3%) (22), Kenya (10.7%) (19), and northwest Ethiopia (12%) (45). One of the lowest prevalence rates was

reported among schoolchildren in Cameron: 4.9% (23). Conversely, this finding was considerably lower than that reported in Afghanistan (48.8% (46)), Chad (60% (21)), and Yemen (66.3% and 80.1% (47, 48)). One of the highest prevalences was 84.7%, and 10.7% of the children had intestinal protozoa and helminth infections, respectively (49). It may be attributed to the variations in environmental conditions, characteristics of the study populations, sanitation and hygiene practices, access to safe water, socioeconomic circumstances, parasite-control activities, and laboratory diagnostic techniques across the different study settings (46).

The predominance of parasites in the current study was consistent with the findings from the study conducted among internally displaced children in Kosti, where *G. lamblia* was also the leading parasite, with a prevalence of 25.0% (33). Similarly, Karrar and Rahim reported a prevalence of 21.1% for *G. lamblia* among children from three police-force camps in Khartoum (28). However, this result differed from findings reported in other Sudanese school populations (30, 32). Meanwhile, *E. histolytica/dispar* was reported as the most common parasite in three studies from southern Sudan, Egypt, and Burkina Faso (29, 44, 49). These variations reinforce the importance of local epidemiological surveillance, as the distribution of intestinal parasite species may differ substantially according to geographical location, environmental conditions, sanitation, diagnostic methods, and patterns of exposure (50, 51).

Regarding helminths, the present data demonstrated that each of *S. mansoni* and *H. nana* was detected in 6.66% of the children. It was similar to the finding in Khartoum State (5.2%) (30) and Kassala (4.7%) (52). In contrast, it was disagreed with in a nationwide survey in Sudan (0.06% (53)), in Sinnar State, Sudan (2.4% (54)), and in Khartoum, Bahri (0.5% (55)). A study conducted among Egyptian schoolchildren reported a low prevalence of *S. mansoni*, which was 0.3% (44), while high prevalence was detected in Ethiopia (59.1% and 34.9%, respectively) (56, 57) and western Kenya (43.7%) (58). This marked difference may reflect variations in freshwater exposure and local transmission ecology. Our finding reported a lower prevalence of *H. nana* than that reported in Al-Kalakla (10.4% (30), 32.6% (31), and more than 4.7% in Shendi (32), 2.2% in Kosti (33)). Research from Burkina Faso found that *H. nana* was the predominant helminth, detected in 6.5% of schoolchildren (49). The result of mixed infections in our study was similar to several previous reports (59–61).

Age was significantly associated with intestinal parasitic infection in the present study ($P = 0.0001$), which is consistent with the recent study from Shendi, Sudan (32), where the prevalence of intestinal parasitic infection declined significantly with increasing age. Younger age may be at greater risk because of less-developed personal hygiene practices and limited awareness of parasite transmission and prevention (59).

In contrast to age, sex was not significantly associated with overall intestinal parasitic infection in the present study; our findings are consistent with previous reports in Sudan (32, 33) and Ethiopia (62). Taken together, these findings suggest that shared environmental and behavioral exposures among children of both sexes may be more important determinants of intestinal parasitic infection than sex itself.

Family educational status, fingernail hygiene, and latrine utilization were also significantly associated with intestinal parasitic infection in the present study, which were similar to previous reports in Egypt (44) and Ethiopia (63, 64). Parental education may contribute to greater awareness of parasite transmission and prevention. Some studies have reported that *G. lamblia* and *E. histolytica* were recovered from fingernail debris (65–67).

Gastrointestinal manifestations were also significant in the present study, which was similar to previous reports (44, 68). These findings suggest that gastrointestinal complaints may help identify children requiring parasitological investigation. The relatively high prevalence of intestinal parasitic infections observed in this study should also be considered within the context of displacement and the ongoing conflict in Sudan, which could be aggravated by poor nutritional status among displaced children in the study area.

Strengths and Limitations

A key strength was the study that was conducted among the first to be conducted among displaced school-aged children. In addition, several protozoal and helminthic parasites, together with demographic, sanitation, hygiene, and symptom variables, were assessed simultaneously and it study also provided data from a vulnerable population for which epidemiological information was often limited. The limitations include the cross-sectional design precluding establishing causal relationships between IPIs and the identified associated factors; our findings may not be generalizable to displaced children in other regions of Sudan because of geographical and population differences. The perianal adhesive tape for detection of *E. vermicularis* and the modified acid-fast staining method for detection of intestinal coccidian parasites were not used. Finally, examination of a single stool specimen examined by direct wet-mount microscopy may have underestimated the true prevalence of intestinal parasitic infections.

Conclusion

Intestinal parasitic infections were relatively high among the school-aged, displaced children studied in Gezira State, Sudan. *G. lamblia* was the predominant parasite, and infection was clustered among younger children. Ages of children and family education were significantly associated with parasitic infection. These findings support integrated control measures for displaced communities, including accessible diagnosis and treatment, safe-water provision, sanitation, hygiene promotion, and targeted health education for children and food.

Abbreviations

IPIs

Intestinal Parasitic infection

G. lamblia

Giardia lamblia

E. histolytica
Entamoeba histolytica
E. vermicularis
Enterobius vermicularis
H. nana
Hymenolepis nana
S. mansoni
Schistosoma mansoni

Declarations

Ethics approval and Consent to Participate

Ethical approval for the study was granted by the Ethics Committee of the Faculty of Medical Laboratory Sciences, University of Gezira (Approval No. 07/026). Authorization to conduct the research was also obtained from the appropriate local health and education authorities. All study procedures were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participating children, while assent was obtained from children when appropriate. Participant privacy and confidentiality were maintained throughout the study, and all collected information was used exclusively for research purposes.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Author Contribution

AAT supervised the study and critically reviewed and edited the final manuscript. SEH and EAA contributed to data collection and preparation of the initial manuscript draft. ANMG performed the advanced statistical analyses, prepared the tables and figures, and managed the references. All authors reviewed and approved the final version of the manuscript.

Acknowledgement

The authors sincerely thank the participating children and their parents or guardians for their cooperation and participation in the study. The authors also acknowledge the local authorities and healthcare personnel for their valuable support and assistance throughout the study.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional restrictions.

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Figures

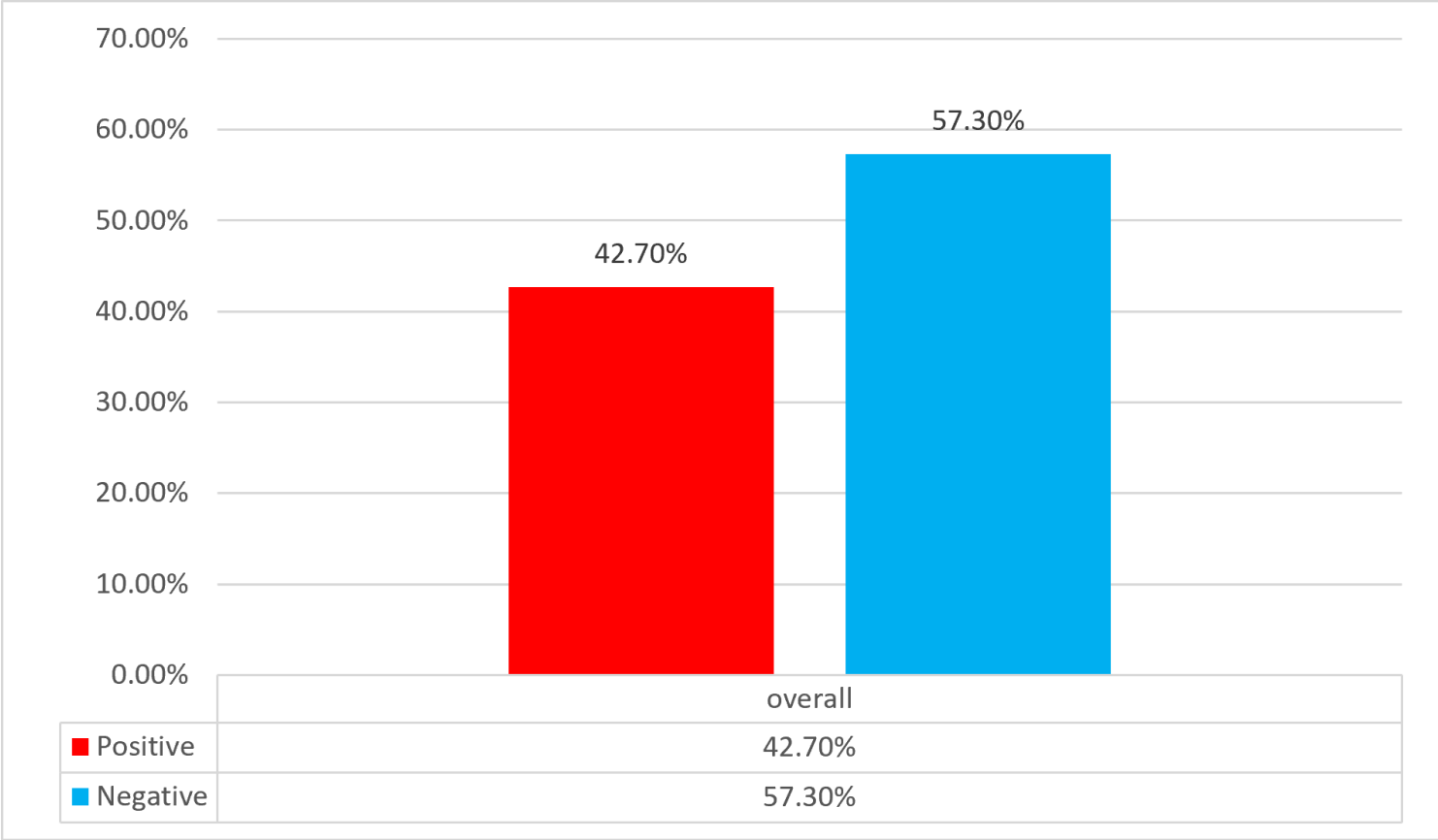


Figure 1

Prevalence of intestinal parasites in school age displaced children in displaced camps near Wadelfadni, Gezira state, Sudan (n = 300).