



OPEN Prevalence and intensity of intestinal and soil-transmitted helminths infection among children in internally displaced camps in Mogadishu Somalia

Bashiru Garba^{1,8,9}, Hodo Aideed Asowe^{2,9}, Najib Isse Dirie^{3,9}✉, Yushau Umar⁴, Abdikani Omar Salah⁵, Ahmed Abdirahim Hussien⁵, Ikram Abdirahman Mohamud Alasow⁵, Fartun Abdullahi Hassan Orey^{6,9}, Jihaan Hassan^{6,9}, Jamal Hassan Mohamoud^{1,9}, Mohamed Hussein Adam^{1,9}, Mohamed Adam Mahamud^{5,9} & Mohamed Mustaf Ahmed^{7,9}

Intestinal and soil-transmitted helminth (STH) infections are significant public health concerns in Somalia and are driven by poor sanitation, contaminated water, and inadequate hygiene practices. This study was undertaken to assess the prevalence and intensity of intestinal and soil-transmitted helminth infections among school-aged children in the Deyniile and Kahda internally displaced persons camps. A well-structured questionnaire was used to collect sociodemographic, behavioral and environmental data from the respondents, while fresh stool samples were collected to detect helminths via the cellophane-based Kato–Katz technique. Bivariate and multivariate logistic regression analyses were used to measure the strength of the associations. The overall prevalence of intestinal and soil-transmitted helminth infection was 72.5% (232/320). A mixed effects logistic regression analysis revealed that fathers with secondary school education ($P = 0.039$; AOR = 0.148; 95% CI 0.024–0.904) and children living in Kahda ($P = 0.033$; AOR = 0.519; 95% CI 0.283–0.950) had a significantly lower risk of helminths infection. The prevalence of helminths in both camps was high. Dirty fingernails ($P = 0.462$; AOR = 0.72; 95% CI 0.30–1.73), eating unwashed fruits ($P = 0.654$; AOR = 0.86; 95% CI 0.45–1.66) and walking barefoot ($P = 0.803$; AOR = 1.13; 95% CI 0.43–2.96) were all not associated with increased risk of infection, including sanitary condition at home ($P = 0.054$; AOR = 2.99; 95% CI 0.98–9.17).

Keywords Soil-transmitted helminthiasis, Neglected tropical diseases, Internally displaced population, Humanitarian crisis, Somalia, Intestinal helminthiasis

Abbreviations

IDP	Internally displaced persons
AOR	Adjusted odds ratio
CI	Confidence interval
COR	Crude odds ratio
IRB	Institutional research ethics review board

¹Department of Public Health, Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

²Department of Nursing and Midwifery, Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

³Department of Urology, Dr. Sumait Hospital, Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

⁴National Veterinary Research Institute Vom, Jos, Plateau State, Nigeria. ⁵Department of Microbiology and Laboratory Sciences, Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

⁶Department of Pediatrics, Dr. Sumait Hospital, Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

⁷Faculty of Medicine and Health Sciences, SIMAD University, Mogadishu, Somalia.

⁸Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Sultan Abubakar Road, City Campus Complex, Sokoto 840212, Sokoto State, Nigeria.

⁹SIMAD Institute for Global Health, SIMAD University, Mogadishu, Somalia. ✉email: drnajib@simad.edu.so

MDA	Mass drug administration
OR	Odds ratio
STH	Soil-transmitted helminthiasis
WHO	World Health Organization
NTD	Neglected tropical diseases
SPSS	Statistical package for social sciences
EPG	Eggs per gram

Intestinal helminthiasis and soil-transmitted helminthiasis are among the most common neglected tropical diseases (NTDs) in Africa, especially among impoverished populations^{1,2}.

Soil-transmitted helminths (STHs) are a group of parasitic worms that pose a significant public health challenge, particularly in tropical and subtropical regions where sanitation and hygiene conditions are poor³. The main species of STH include *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and hookworms (*Ancylostoma duodenale*, *Ancylostoma ceylanicum*, and *Necator americanus*). These parasites are transmitted through contaminated soil, often because of improper disposal of human feces and inadequate sanitation practices⁴. The public health burden of STH infections is enormous, with millions of people affected globally, particularly in resource-limited settings.

Hymenolepis nana on the other hand is the cestode associated with human hymenolepiasis, and infection usually follows fecal-oral transmission after the ingestion of food or water contaminated with infective eggs from the feces of humans and rodents^{5,6}. Infection is most common among the pediatric population, especially those living in resource-poor countries and settings with poor sanitation and hygiene⁷. The disease is one of the most prevalent cestodes globally, infecting over 75 million people in 78 countries⁶.

Morbidities attributable to these parasites primarily result from chronic infections, which can lead to significant health issues such as malnutrition, anemia, impaired growth, and cognitive deficits in children^{3,4,7}. In most cases, infection is asymptomatic; however, heavy infections may cause gastrointestinal signs characterized by abdominal cramps, diarrhea, nausea, and vomiting⁸. Recent World Health Organization (WHO) estimates indicate that STH affects more than 1.5 billion people, accounting for approximately 24% of the world's population, with the majority living in low-income countries⁹. Hookworms, for example, attach to the intestinal wall and consume blood, leading to iron deficiency anemia¹⁰. The resulting chronic blood loss can result in fatigue, weakness, dizziness, and impaired cognitive function^{11,12}. In severe cases, especially in children and pregnant women, anemia can lead to serious health consequences, such as developmental delays and complications during pregnancy¹². Furthermore, STHs, especially *Ascaris lumbricoides* and *Trichuris trichiura*, compete for nutrients in the host's intestines, thereby impairing the ability of the host body to absorb essential vitamins and minerals. This often leads to malnutrition, especially in children, resulting in stunted growth and poor physical development^{13–15}. Although direct mortality from STH infections is relatively low, severe cases can result in life-threatening complications, such as bowel obstruction due to *Ascaris* infection or severe anemia from hookworms^{9,15}. Indirect mortality may also occur through the exacerbation of other conditions, such as malnutrition or infection-related complications.

In Somalia, approximately 5 to 6 million people live in areas that are highly endemic for intestinal and soil-transmitted helminths¹⁶. The World Health Organization, in collaboration with the Somalia Ministry of Health and Human Services, undertook a mapping exercise between 2016 and 2017 to determine the prevalence of neglected tropical diseases, and the outcome of this exercise revealed unexpectedly high cases of intestinal schistosomiasis and hookworms¹⁶. A survey conducted by Ilardi et al. revealed that 85% of the population of two Somali communities harbor soil and intestinal helminth infections, with *Trichuris trichiura* accounting for 59% of the infections¹⁷. Although there is a dearth of national data regarding the status of this important neglected tropical disease, several small institution-based surveys have demonstrated a high disease prevalence. This includes a prevalence of intestinal parasitic infections of 35% and 30.6% for single and multiple infections, respectively, among children in pastoralist and agro-pastoralist communities in the Adadle woreda of the Somali Regional State of Ethiopia¹⁸. Similarly, a 6-year retrospective survey of intestinal parasites among patients attending tertiary hospitals in Somalia revealed that 7% of 37,398 patients tested for parasitic intestinal infections were positive for at least one species of intestinal parasite, with *Giardia duodenalis*, *Entamoeba histolytica*, *Trichuris trichiura*, *Hymenolepis nana*, and *Ascaris lumbricoides* being the most common¹⁹.

To overcome morbidities from intestinal and soil-transmitted helminths, the Federal Government of Somalia, with support from the World Health Organization (WHO), has conducted mass drug administration campaigns since 2017. Over an 18-day period of the mass campaign, essential medicines, such as praziquantel and metronidazole, were administered to approximately 3 million vulnerable school-aged children between the ages of 5 and 14 years, as well as to adults in 39 districts of the country. These interventions were part of the global effort to eradicate this important public health challenge in line with Sustainable Development Goals. Although these interventions were able to temporarily reduce the prevalence and intensity of soil and intestinal helminth infections, the disease has persisted, as demonstrated by a recently published 5-year retrospective survey, which revealed an overall prevalence of 11.9% (6,766/56,824), with *Giardia lamblia* having the highest prevalence 60.84% (4,116/6,766), followed by *Entamoeba histolytica* 33.07% (2,238/6,766) and *Ascaris lumbricoides* 3.18% (215/6,766)²⁰. This finding suggests the need for sustained surveillance and stringent monitoring and evaluation of the situation in the country.

Therefore, this study was undertaken to estimate the prevalence of intestinal and soil-transmitted helminth infections, the intensity of the infections and the behavioral and environmental risk factors among children living in IDP settlements in Mogadishu, Somalia. This is because children in internally displaced persons (IDPs) are particularly vulnerable to helminth infections due to several compounding factors, including poor hygiene and sanitation, overcrowding, and limited access to basic healthcare services. The findings of this cross-sectional

study will be useful for decision-makers and humanitarian actors in allocating resources and providing targeted interventions to reduce the direct and indirect impacts of these infections as well as improve the overall public health outcomes in Somalia.

Methods

Ethical approval and consent to participate

The study was approved by the ethical committee of the SIMAD University Institutional Review Board (Ref: 2023/SU-IRB/FMHS/P034). Ethical considerations were addressed by providing free drugs against intestinal protozoa to participants who were positive. Written informed consent was obtained from the parents or guardians of the selected study children. All methods in the study were performed in accordance with the relevant guidelines and regulations.

Study setting

This study was conducted in the Deyniile and Kahda districts in Mogadishu Somalia. Deyniile and Kahda are two districts that house the largest population of IDPs in Somalia. Recent IDP site verification identified 1,979 IDP sites, with the majority (1115) located in Deyniile and 864 in Kahda. The two camps host 230,473 households with a total of 1,247,669 individuals²¹ (Fig. 1).

Study design and sample size

A cross-sectional study was undertaken by recruiting children aged 17 years and younger whose parents or guardians were residents of the Deyniile and Kahda IDP camps. The minimum sample size to achieve the aim of this study was computed via the single population proportion formula on the basis of a reported prevalence of 29.7% STH among children (P) and a 5% margin of error (e).

$$n = \frac{Z^{2*} p * (1 - p)}{e^2}$$

Therefore, the minimum sample size was found to be 320.

Sampling technique and method of data collection

One hundred and sixty (160) children from each of the IDP camps were selected via a systematic random sampling technique, where after the first house with children was conveniently chosen, every tenth household with at least one child was selected if the head of household consented. Children aged 17 years and younger during the data collection period were included in the study, while those with a history of recent deworming were excluded from the study.

The participants' households were visited by trained data collectors to administer the questionnaire. A validated structured questionnaire developed after extensive literature review and review by expert researchers was uploaded to Google Forms and used to collect data through face-to-face interviews with mothers/caretakers of the selected children. The data collected include data on environmental factors, such as domestic water sources and storage containers; waste disposal; the hygiene conditions of the households and their surroundings; and the type of toilet facility as well as animal ownership. Similarly, the questionnaire also addressed participants' household demographic risk factors.

Laboratory stool examination

Following demonstrations to the children's mothers or caregivers on how to aseptically collect stool without extraneous contaminants such as soil or urine, a sterile plastic screw-capped stool container labeled with the corresponding identification number of the questionnaire details was given to the parents for stool specimens. The collected stool sample was transported in an ice box immediately after collection to the Microbiology Laboratory, Faculty of Medicine and Health Sciences, SIMAD University Mogadishu, Somalia, for diagnosis. All diarrheic samples and samples contaminated with urine, water, or sand was discarded. In accordance with the recommended Kato-Katz technique by the WHO, a single thick stool smear was prepared according to the manufacturer's instructions²². The prepared cellophane thick stool smear was kept at room temperature within 30 min under bright light to allow for sample clearing before examination under a bright-field microscope. The volume of stool filled into the template before smearing was 41.7 mg. The number of helminth eggs present in the prepared glass slide was counted and recorded, while the intensity of infection was computed by multiplying the number of eggs found in the fecal smear by a factor of 24 to obtain the number of eggs per gram of feces. This count was used for classifying the infection into either light, moderate or heavy infections (Table 3).

Data analysis

The questionnaire data were retrieved from the Google Form in the form of an Excel spreadsheet, coded and entered into SPSS v27 for analysis. All categorical variables were analyzed via descriptive statistics as frequencies and percentages. Univariable and multivariable logistic regression were used to assess the associations between infection and sociodemographic and behavioral risk factors, while a P value of less than 0.05, indicates statistical significance.

The data were statistically analyzed using bivariate and multivariate logistic regression to obtain the crude odds ratios and adjusted odds ratios. All variables from socio-demographic characteristics of participants and the behavioural and environmental risk factors in the bivariate analysis were fitted into the multivariate logistic regression model to identify independent predictors of intestinal and STH infection among the participants²³.

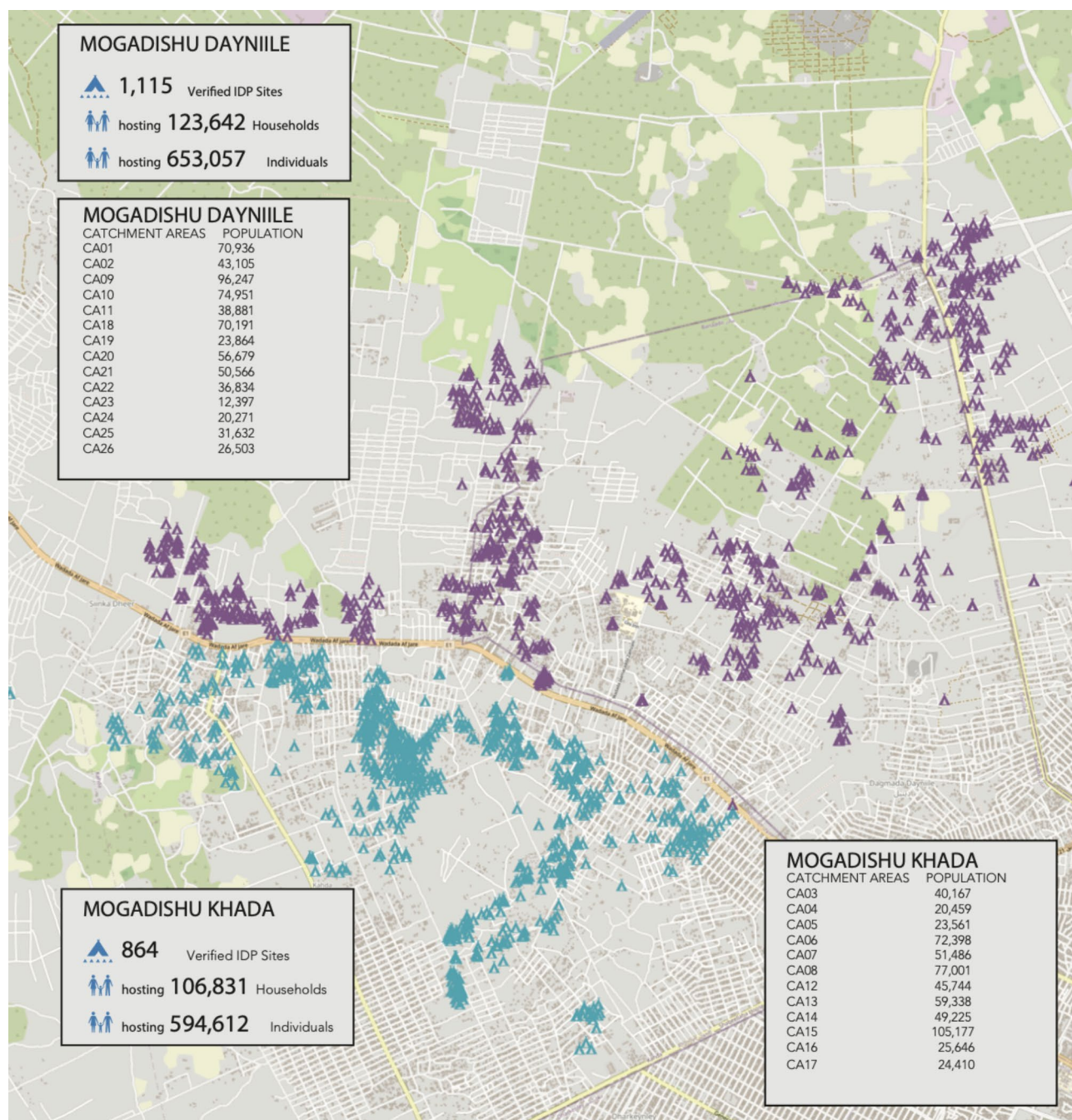


Fig. 1. Verified IDP sites in Deyniile and Kahda based on CCCM Cluster, Somalia-Nov. 2023 Report²¹.

COR was obtained by considering only the outcome (Intestinal and STH infection) and one exposure variable (independent variable) at a time, $COR = (\text{Odds of outcome in exposed group}) / (\text{Odds of outcome in unexposed group})$ and COR does not control for confounder. Whereas adjusted Odds ratios on the other hand was calculated using multivariate logistic regression analysis, which allows for the simultaneous control of multiple confounders by adding all the independent variables (exposures) into the equation.

Results

A total of 320 participants from 320 households, comprising of 161 children from Deyniile and 159 children from Kahda IDP camps were involved in the study. The descriptive analysis of the results revealed that the majority of the participants 55% (177/320) were girls. The evaluation of age revealed that 61% (195/320) were under 5 years, 34% (109/320) were between the ages of 6–10 years, and 5% (16/320) were between 11 and 15 years. The detailed social and demographic characteristics of the participants and their households are shown in Table 1.

Variable	Category	Internally displaced camp		Total (%)
		Deyniile-N = 161 (%)	Kahda - N = 159 (%)	
Sex	Male	69(42.8)	74(46.5)	143(44.7)
	Female	92(57.2)	85(53.5)	177(55.4)
Age category	Under 5 years	107(66.5)	88(55.3)	195(60.9)
	6–10 years	49(30.4)	60(37.7)	109(34.1)
	11–15 years	5(3.1)	11(7.0)	16(5.0)
Level of child education	No school	101(62.7)	85(53.5)	186(58.1)
	Primary	1(0.6)	1(0.6)	2(0.6)
	Quranic/Dugsi	59(36.7)	73(45.9)	132(41.3)
Level of Father's education	No school	146(90.7)	156(98.1)	302(94.4)
	Primary school	8(5.0)	3(1.9)	11(3.4)
	Secondary school	7(4.3)	0(0.0)	7(2.2)
Level of mother's education	No school	148(91.9)	159(100)	137(95.9)
	Primary school	12(7.5)	0(0.0)	12(3.8)
	Secondary school	1(0.6)	0(0.0)	1(0.3)
Father's occupation	Businessman	22(13.7)	9(5.7)	31(9.7)
	Farmer	23(14.3)	8(5.0)	31(9.7)
	Laborer	12(7.5)	20(12.6)	32(10.0)
	Teacher	21(13.0)	32(20.1)	53(16.6)
	Unemployed/Others	83(51.5)	90(56.6)	173(54.0)
Mother's occupation	Business	16(9.9)	25(15.7)	41(12.8)
	Unemployed	145(90.1)	134(84.3)	279(87.2)
Family size	0–5	80(49.7)	55(34.6)	135(42.2)
	More than 5	81(50.3)	104(65.4)	185(57.8)
Family income (USD)	Less than 100	97(60.2)	154(96.9)	251(78.4)
	100–500	64(39.8)	5(3.1)	69(21.6)
Duration of stay in camp (years)	0–3 years (1–36 month)	158(98.1)	158(99.4)	316(98.7)
	More than 4 years (> 37 months)	3(1.9)	1(0.6)	4(1.3)

Table 1. Sociodemographic characteristics of the participants at the Deyniile & Kahda IDP sites, Mogadishu, Somalia (2024).

With respect to the environmental and behavioral risk factors, the results revealed that 16% (52/320) of the households kept animals, 46% (148/320) had poor sanitary conditions around their homes, and 92% (294/320) practiced open defecation. Similarly, 65.6% (110/320) of the children washed their hands after defecation, whereas 82.5% (264/320) washed their hands before and after eating. Most of the children 315/320 (98.4%) had no history of deworming, and 26.9% (86/320) had dirty fingernails (Table 2).

Prevalence and intensity of intestinal and soil-transmitted helminth infection

Among the 320 children enrolled in the study, 72.5% (232/320) were infected with one or more STHs or intestinal helminths. With respect to single infection, 74 (31.9%), 54 (23.3%), 1 (0.4%), and 21 (9.1%) of the children had *T. trichiura*, *A. lumbricoides*, hookworm, and *H. nana* infection alone. The prevalence rates of *A. lumbricoides*, *T. trichiura*, *H. nana* and hookworm infestations were 44.7%, 15.9%, 6.6%, and 1.9%, respectively (Table 3). The prevalence of each species of parasite and the intensity of infection among the infected children are presented in Table 3.

The intensity among the STH and intestinal helminth infections varies across the various parasites (Ascariasis, Hookworm and Trichuriasis intensity distributions). The median helminth intensity is as follows: 192 eggs per grams for Ascariasis, 24 eggs per grams for Hookworm, 192 eggs per grams for Hymenolepiasis, and 240 eggs per grams for Trichuriasis.

The results of the Kruskal–Walli's analysis, with a Chi-Square value 10.8, degree of freedom 3 and P value of 0.03, indicate statistically significant differences between the helminths infection Furthermore, statistically significant differences were detected between the ascariasis and the hookworm, with p values 0.00932, and between the hookworm and hymenolepis and the hookworm and trichuriasis (Fig. 2).

In the two IDP camps involved in this study, the intensity of infection was generally light for all the helminths surveyed, except for *T. trichiura*, which had 3.5% moderate infection, indicating an infection with 1000 to 9999 eggs per gram (EPG) of feces. The prevalence of helminth infection also varied per IDP camp, with the highest prevalence observed in Deyniile 78.3% (126/161), whereas that in Kahda was 66.7% (106/159) (Table 4).

Associations between sociodemographic factors and the risk of helminth infection

Bivariate and multivariate mixed effects logistic regression analyses of sociodemographic factors influencing helminth infection among children in Deyniile and Kahda IDP camps, Mogadishu, Somalia, revealed that fathers

Variable	Category	Status of intestinal and STH infection		Total (%)
		Negative-N = 88 (%)	Positive – N = 232 (%)	
Keeping of animals	Yes	16 (30.8)	36(69.2)	52(16.3)
	No	72(26.9)	196(73.1)	268(83.7)
History of deworming	Yes	1(20.0)	4(80.0)	5(1.6)
	No	87(27.6)	228(72.4)	315(98.4)
Child swimming in water	Yes	2(11.8)	15(82.2)	17(5.3)
	No	86(28.4)	217(71.6)	303(94.7)
Washing hands after defecation	Yes	64(30.5)	146(69.5)	210(65.6)
	No	24(21.8)	86(78.2)	110(34.4)
Washing hands before and after eating	Yes	77(29.2)	187(70.8)	264(82.5)
	No	11(19.6)	45(81.4)	56(17.5)
Hand washing after soil contact	Yes	22(20.8)	84(79.2)	106(33.1)
	No	66(30.8)	148(69.2)	214(66.9)
Dirty fingernails	Yes	15(17.4)	71(82.6)	86(26.9)
	No	73(31.2)	161(68.8)	234(73.1)
Eating unwashed fruits	Yes	24(20.7)	92(79.3)	116(36.3)
	No	64(31.4)	140(68.6)	204(63.7)
Wearing foot wears	Yes	61(32.8)	125(67.2)	186(58.1)
	No	27(20.1)	107(79.9)	134(41.9)
Sources of drinking water	Municipal tap water	52(28.3)	132(71.7)	184(57.5)
	Water trucking	36(27.1)	97(72.9)	133(41.6)
	Well water	0(0.0)	3(100)	3(0.9)
Water storage	Plastic containers	6(17.1)	29(82.9)	35(10.9)
	Tanks	82(28.8)	203(71.2)	285(89.1)
Coverage of water container	Covered	65(31.0)	145(69.0)	210(65.6)
	Uncovered	23(20.9)	87(79.1)	110(34.4)
Sanitary condition at home and outside	Good	59(34.3)	113(65.7)	172(53.8)
	Poor	29(19.6)	119(80.4)	148(46.3)
Type of toilet	Open defecation	79(26.9)	215(73.1)	294(91.9)
	Pit latrine	0(0.0)	2(100)	2(0.6)
	Others	9(37.5)	15(62.5)	24(7.5)
Sewage disposal	Dustbin	3(37.5)	5(62.5)	8(2.5)
	Garbage pit	44(36.4)	77(63.6)	121(37.8)
	Open field outside compound	29(19.7)	118(80.3)	147(45.9)
	Others	12(27.3)	32(72.7)	44(13.8)

Table 2. Behavioral and environmental risk factors related to STH and intestinal helminth infection in children at the Deyniile & Kahda IDP sites, Mogadishu, Somalia (2024).

Parasite	Positive infection n (%)	Intensity of infection		
		Light	Moderate	Heavy
<i>A. lumbricoides</i>	143 (44.7)	143 (46.9)	0 (0.0)	0 (0.0)
Hookworm	6 (1.9)	6 (1.9)	0 (0.0)	0 (0.0)
<i>H. nana</i>	21 (6.6)	20 (6.3)	0 (0.0)	0 (0.0)
<i>T. trichiura</i>	51 (15.9)	154 (48.1)	11 (3.4)	0 (0.0)
<i>A. lumbricoides</i> : 1 to 4999 EPG (light), 5000 to 49,999 EPG (moderate), and \geq 50,000 EPG (heavy)				
<i>Hookworm</i> : 1 to 1999 EPG (light), 2000 to 3999 EPG (moderate), and \geq 4000 EPG (heavy)				
<i>T. trichiura</i> : 1 to 999 EPG (light), 1000 to 9999 EPG (moderate), and \geq 10,000 (heavy)				
<i>H. nana</i> : 1–1999 (light), 2000–9999 (moderate), and \geq 10,000 (heavy)				

Table 3. Prevalence of STH and intestinal helminth species among children in Deyniile and Kahda IDP camps, Mogadishu, Somalia (2024).

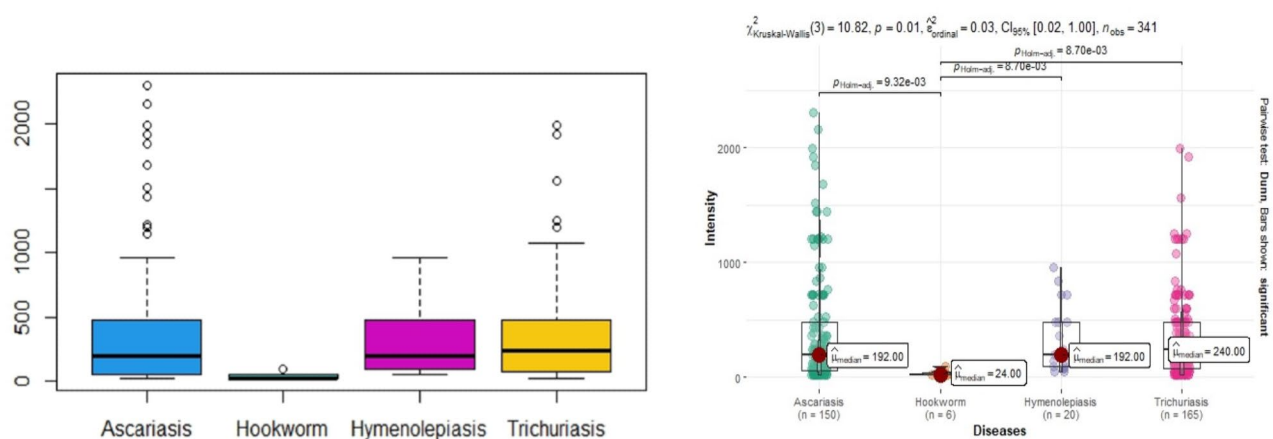


Fig. 2. Pairwise test with Dunn bars showing statistical significance (a). X^2 = Kruskal Wallis value, df = Degree of freedom, P = p – value, CL95% = 95% Confidence Interval, nobs = Total number of participants (b).

Variable	Category	Status of intestinal and STH infection		COR (95% CI)	P value	AOR (95% CI)	P value
		Negative (%)	Positive (%)				
Sex	Male	38(26.6)	105(73.4)	1		1	
	Female	50(28.2)	127(71.8)	0.919(0.560–1.508)	0.739	0.84(0.49–1.410)	0.498
Age category	Under 5 years	54(27.7)	141(72.3)	1		1	
	6–10 years	27(24.8)	82(75.2)	1.163(0.680–1.988)	0.581	0.926(0.407–2.105)	0.854
	11–15 years	7(43.8)	9(56.2)	0.494(0.175–1.388)	0.179	0.506(0.144–1.779)	0.288
Residence*	Deyniile	35(21.7)	126(78.3)	1		1	
	Kahda	53(33.3)	106(66.7)	0.556(0.337–0.915)	0.021	0.519(0.283–0.950)	0.033
Level of child education	No school	54(29.0)	132(79.0)	1		1	
	Primary	1(50.0)	1(50.0)	0.409(0.025–6.659)	0.529	1.684(0.063–45.00)	0.756
	Quranic/Dugsi	33(25.0)	99(75.0)	1.227(0.740–2.034)	0.427	1.461(0.661–3.227)	0.349
Level of Father's education*	No school	79(26.2)	223(73.8)	1		1	
	Primary school	5(45.5)	6(54.5)	0.425(0.126–1.432)	0.167	0.310(0.084–1.139)	0.078
	Secondary school	4(57.1)	3(42.9)	0.266(0.058–1.213)	0.087	0.148(0.024–0.904)	0.039
Level of mother's education	No school	86(28.0)	221(72.0)	1		1	
	Primary school	2(16.7)	10(83.3)	1.946(0.418–9.062)	0.396	2.456(0.420–14.35)	0.318
	Secondary school	0(0.0)	1(100)	-	-	-	-
Father's occupation	Businessman	8(25.8)	23(74.2)	1		1	
	Farmer	10(32.3)	21(67.7)	0.730(0.243–2.199)	0.576	0.660(0.199–2.195)	0.498
	Laborer	10(31.3)	22(68.8)	0.765(0.255–2.295)	0.633	0.872(0.255–2.984)	0.827
	Teacher	16(30.2)	37(69.8)	0.804(0.297–2.177)	0.668	0.883(0.282–2.768)	0.831
	Unemployed/Others	44(25.4)	129(74.6)	1.020(0.425–2.444)	0.965	1.223(0.442–3.382)	0.698
Mother's occupation	Business	14(34.1)	27(65.9)	1		1	
	Unemployed	74(26.5)	205(73.5)	1.436(0.715–2.887)	0.309	1.485(0.699–3.155)	0.304
Family size	0–5	40(29.6)	95(70.4)	1		1	
	More than 5	48(25.9)	137(74.1)	1.202(0.733–1.971)	0.466	1.252(0.726–2.160)	0.419
Family income	Less than 100	72(28.7)	179(71.3)	1		1	
	100–500	16(23.2)	53(76.8)	1.332(0.715–2.483)	0.366	1.300(0.566–2.987)	0.536
Duration of stay in camp	0–3 years (1–36 month)	87(27.5)	229(72.5)	1		1	
	More than 4 years (37 months and above)	1(25.0)	3(75.0)	1.140(0.117–11.10)	0.909	0.721(0.063–8.287)	0.793

Table 4. Bivariate and multivariate analyses of sociodemographic risk factors associated with STH and intestinal infection among children in Deyniile & Kahda IDP camps, Mogadishu, Somalia (2024). Notes: * Variables that are statistically significant; Bold- Statistically significant P-values; COR-Cumulative Odds Ratio; AOR- Adjusted Odds Ratio.

Variable	Category	Status of intestinal and STH infection		COR (95% CI)	P value	AOR (95% CI)	P value
		Negative-N=88 (%)	Positive -N= 232 (%)				
Keeping of animals	Yes	16(30.8)	36(69.2)	1		1	
	No	72(26.9)	196(73.1)	1.21(0.63–2.31)	0.564	1.34(0.66–2.72)	0.417
History of deworming	Yes	1(20.0)	4(80.0)	1		1	
	No	87(27.6)	228(72.4)	0.66(0.07–5.94)	0.707	1.14(0.07–28.8)	0.823
Child swimming in water	Yes	2(11.8)	15(88.2)	1		1	
	No	86(28.4)	217(71.6)	0.34(0.08–1.50)	0.154	0.22(0.04–1.32)	0.098
Washing hands after defecation	Yes	64(30.5)	146(69.5)	1		1	
	No	24(21.8)	86(78.2)	1.57(0.92–2.69)	0.101	1.38(0.54–3.45)	0.502
Washing hands before and after eating	Yes	77(29.2)	187(70.8)	1		1	
	No	11(19.6)	45(80.4)	1.68(0.83–3.43)	0.149	1.05(0.39–2.81)	0.926
Hand washing after soil contact	Yes	22(20.8)	84(79.2)	1		1	
	No	66(30.8)	148(69.2)	0.59(0.34–1.02)	0.059	1.91(0.65–5.61)	0.242
Dirty fingernails*	Yes	15(17.4)	71(82.6)	1		1	
	No	73(31.2)	161(68.8)	0.47(0.25–0.87)	0.016	0.72(0.30–1.73)	0.462
Eating unwashed fruits*	Yes	24(20.7)	92(79.3)	1		1	
	No	64(31.4)	140(68.6)	0.57(0.33–0.98)	0.041	0.86(0.45–1.66)	0.654
Wearing foot wears*	Yes	61(32.8)	125(67.2)	1		1	
	No	27(20.1)	107(79.9)	1.93(1.45–3.26)	0.013	1.13(0.43–2.96)	0.803
Sources of drinking water	Municipal tap water	52(28.3)	132(71.7)	1		1	
	Water trucking	36(27.1)	97(72.9)	1.06(0.64–1.75)	0.815	0.98(0.54–1.77)	0.939
	Well water	0(0.0)	3(100)	-	-	-	-
Water storage	Plastic containers	6(17.1)	29(82.9)	1		1	
	Tanks	82(28.8)	203(71.2)	0.51(0.21–1.28)	0.152	0.50(0.18–1.37)	0.175
Coverage of water container	Covered	65(31.0)	145(69.0)	1		1	
	Uncovered	23(20.9)	87(79.1)	0.59(0.34–1.02)	0.057	0.71(0.27–1.88)	0.496
Sanitary condition at home and outside*	Good	59(34.3)	113(65.7)	1		1	
	Poor	29(19.6)	119(80.4)	2.14(1.28–3.58)	0.004	2.99(0.98–9.17)	0.054
Type of toilet	Open defecation	79(26.9)	215(73.1)	1		1	
	Pit latrine	0(0.0)	2(100)	-	-	-	-
	Others	9(37.5)	15(62.5)	0.61(0.26–1.46)	0.267	0.33(0.10–1.16)	0.085
Sewage disposal	Dustbin	3(37.5)	5(62.5)	1		1	
	Garbage pit	44(36.4)	77(63.6)	1.05(0.24–4.61)	0.948	1.27(0.17–9.51)	0.818
	Open field outside compound	29(19.7)	118(80.3)	2.44(0.55–10.8)	0.239	2.44(0.31–19.1)	0.394
	Others	12(27.3)	32(72.7)	1.60(0.33–7.75)	0.559	1.26(0.16–9.95)	0.829

Table 5. Bivariate and multivariate analyses of risk factors related to intestinal and STH infection in children in Deyniile and Kahda IDP camps, Mogadishu, Somalia (2024). Notes: * Variables that are statistically significant; Bold- Statistically significant P-values; COR-Cumulative Odds Ratio; AOR- Adjusted Odds Ratio.

with secondary level education ($P=0.039$; AOR=0.148; 95% CI 0.024–0.904) and children living in Kahda ($P=0.033$; AOR=0.519; 95% CI 0.283–0.950) had significantly lower risk of helminth infections. Residents of a household with more than five members (AOR=1.252; 95% CI 0.726–2.160), female gender (AOR=0.84; 95% CI 0.49–1.410), and family income (AOR=1.300; 95% CI 0.566–2.987) (Table 4) were all found not to be associated with increased or decreased risk of helminths infection.

Potential behavioral and environmental risk factors for intestinal and soil-transmitted helminth infection in children

The results of the logistic regression analysis are shown in Table 5. Children without dirty fingernails ($P=0.462$; AOR=0.72; 95% CI 0.30–1.73) and not eating unwashed fruits ($P=0.654$; AOR=0.86; 95% CI 0.45–1.66) and not wearing footwears ($P=0.803$; AOR=1.13; 95% CI 0.43–2.96) were found to not be significant risk factors for helminths infection. On the other hand, despite having poor sanitary conditions both within and outside their homes ($P=0.054$; AOR=2.99; 95% CI 0.98–9.17) showing potential association ($p<0.05$), this was also found to not constitute a significant risk for helminths infection. Furthermore, all the remaining independent variables were found not to be statistically significant contributors of intestinal and STH infection in this current study.

Discussion

In this study, the prevalence of intestinal and soil-transmitted helminth infection and helminth intensity as well as sociodemographic, environmental and behavioral risk factors among children living at the two major

internally displaced people in Mogadishu, Somalia, were assessed. The prevalence of any intestinal or STH infection was found to be 72.53%, and only *T. trichiura* was found to have moderate infection among all children (3.5%).

Although recent data on the prevalence of helminth infection are scarce, our study revealed that intestinal- and soil-transmitted helminth infections persist among children in the Deyniile and Kahda IDP settlements in Mogadishu, Somalia. This result is lower than the 85% prevalence of intestinal helminths reported by Ilardi et al.¹⁷. This finding may suggest a slight improvement as a result of helminth prevention interventions as well as better water resources and sanitation infrastructure and practices in the area. However, this finding is considerably higher than the 11.9% reported in a 4-year retrospective survey among patients assessed at the laboratory of a tertiary hospital in Somalia²⁰. This disparity is likely because only 5.3% of the participants studied in the 4-year retrospective study were children (0–15 years) in comparison with the present study. Many studies have shown that children have higher prevalence of helminths infection due to poor hygiene practices, immature immune systems, and frequent exposure to contaminated environment^{24–27}.

The prevalence of any of the intestinal or STH infections in the Mogadishu Deyniile and Kahda IDP camps was light, with only *T. trichiura* showing a moderate intensity infection among 3.1% of the children. This may not be unconnected with the ongoing efforts aimed at reducing the prevalence of neglected tropical diseases in Somalia championed by the WHO in collaboration with the Somalia Ministry of Health. One such intervention is the mass drug (praziquantel and metronidazole) administration campaign to eradicate schistosomiasis and soil-transmitted helminth infections that was launched in 2017 through 2022, which targeted approximately 2.48 million school-aged children (aged between 5 and 14 years) and adults in 39 districts of Somalia²⁸. These interventions will help reduce the reservoir of infection and interrupt disease spread. In addition to offering medicines to control and eradicate helminth infections, the stakeholders also embark on intense public awareness of these diseases, especially among the most vulnerable groups, including internally displaced persons²⁸.

The prevalence of STH infection in this study was similar to the 75.6% reported among primary school children in Uttar Pradesh, India, whereas it was lower than the 89.6% reported in a survey of intestinal parasitism among school children in an internally displaced person camp in Benin city, Nigeria^{25,29}. Important to highlight that the high prevalence in the Nigerian study could be because it included 8 different intestinal parasites while the current study investigated only four STHs and intestinal parasites. The disagreements in the prevalence of helminth infections in these studies could be attributed to the high helminth prevalence in Somalia due to poor sanitation, inadequate access to clean water, overcrowded living conditions in IDP camps, and limited health services. These factors are driven by the protracted conflicts, droughts and famine that have affected the country in recent years^{30,31}. The ensuing humanitarian crisis facilitated the transmission of intestinal and soil-transmitted helminths, compounded by poverty, insufficient public health infrastructure, and a lack of awareness of hygiene and preventive measures^{17,28,32}. On the other hand, the higher prevalence in Benin city was attributed to the presence of resistant cysts in the camp, which are able to withstand harsh environmental conditions in addition to poor personal and environmental hygiene, host genetic variability and geographical factors^{33,34}.

In the present study, *A. lumbricoides* was the predominant STH species detected (44.7%), followed by *T. trichiura* (22.9%) and hookworms (1.9%), whereas the prevalence of the intestinal helminth *H. nana* was 6.6%. This finding is similar to studies in China, Ethiopia and India but differs from results in Benin city, Nigeria, and Northwestern Ethiopia where *Entamoeba histolytica* (64.3%), and *Giardia duodenalis* (57.0%), and hookworms were predominant respectively^{29,35–37}. The findings in this study are also slightly dissimilar from recent reports in Somalia, where *Giardia lamblia* was found to have the highest prevalence (60.84%) in a five-year period, followed by *Entamoeba histolytica* (33.07%) and *Ascaris lumbricoides* (3.18%)^{20,36,38}. The fact that 58.1% of the children in our study reported wearing shoes while playing outside may have contributed to the reduced number of hookworm infections observed. Interestingly, some of the children in our study were found to harbor *Hymenolepis nana* infections, while no infection with *Strongyloides stercoralis* was detected, probably due to the limitations of the Kato–Katz technique^{38,39}.

The high prevalence of helminth infection recorded in this study may be due to the lack of sustained mass drug administration (MDA) for helminths, especially among vulnerable displaced populations at the greatest risk. Approximately 30.1% of the children with one or more helminth infections were found to have dirty fingernails. Dirty fingernails can harbor soil, fecal matter, and helminth eggs, which act as a significant pathway for soil-transmitted helminth (STH) infections^{40,41}. This finding is consistent with a study that assessed fingernail contamination with soil-transmitted helminths in schoolchildren in Ethiopia, where 24.3% of the children had *A. lumbricoides*, *T. trichiura*, and hookworm⁴¹. However, the intensity of the infections was generally light, with only 3.5% showing moderate-intensity infection. The fact that children often put their hands in their mouths or eat without washing their hands facilitates the ingestion of infective eggs or larvae, perpetuating the transmission cycle. This risk is heightened in settings such as IDP settlements with poor hygiene, inadequate sanitation, and limited access to clean water.

Our study also assessed the associations of potential risk factors with the prevalence of intestinal and STH infections. Some of the sociodemographic variables evaluated were parents' education and occupation, family income, home of residence, and duration of stay in the camp. For all the sociodemographic variables studied, no associations were found except for fathers' education and place of residence. This finding is similar to studies in Eastern Ethiopia and Indonesia^{38,42}. However, in terms of place of residence, the number of infected children was greater in Deyniile ($n = 126$) than in Kahda ($n = 106$) IDP camps. Deyniile and Kahda are the largest IDP camps in Somalia, housing 273,181 families⁴³. Unfortunately, the water, hygiene and sanitation conditions of IDP camps are poor, with low access to portable drinking water and rampant open defecation⁴⁴. One possible explanation of the prevalence disparity is the fact that Deyniile has higher number of verified IDPs (Deyniile-1, 115 vs. Kahda-864), households (Deyniile-123, 642 vs. Kahda-106, 831), and individuals (Deyniile-653, 057 vs. Kahda-594, 612) according to recent estimations²¹. Overcrowding in IDP camps leads to competition for

scarce resources, increases helminth infections due to poor sanitation, inadequate clean water, close contact, and increased environmental contamination among other things^{45,46}. With respect to the significant association between fathers' education and helminth infection, studies have shown that a father's education level is one of several factors that can be associated with the prevalence of helminths in children, particularly as it affects the knowledge and awareness of helminth parasites^{47,48}. This finding is consistent with the findings of Ayele et al. and Andargie et al. in Ethiopia, who reported that children whose fathers are illiterate are at greater risk of infection with helminths than are those whose fathers are literate^{24,48}.

When we analyzed the associations between helminth infection and other environmental and behavioral risk factors, we found that most of the variables were not statistically significant after adjusting the odds ratio, except for the unsanitary condition of one's home which showed potential association, but even this does not seem to significantly increase the risk of intestinal and soil-transmitted helminth infection. While, the p-value indicate possible association, the wide confidence interval implies variability and potential imprecision in the estimate possibly due to the relatively small sample size. Although studies in Malaysia and Honduras indicate that open defecation can increase the risk of helminth infection twofold, in this study, no association was found^{49,50}. Additionally, from multivariate analysis, we did not find an association between the source of drinking water, storage of water, history of deworming or keeping livestock and the risk of intestinal and STH infection. This finding is consistent with studies conducted in Malaysia and Indonesia^{38,50}.

Strengths and limitations

The cross-sectional study design used in this study is not able to generate evidence of a causal relationship and cannot account for seasonal variations in helminth transmission, which may lead to under- or overestimation of prevalence. Second, the sensitivity of the Kato-Katz technique decreases with low-intensity infections, potentially underestimating its prevalence. It is also ineffective in detecting *Strongyloides stercoralis* and other helminths that are not shedding eggs. Hence, using more sensitive assays like molecular techniques (conventional and quantitative polymerase chain reaction) is recommended for better diagnosis and differentiation of helminths species including strongyloides. Finally, the relatively small sample size used to generate evidence on the infection status of children in this study due the high-security risk may have resulted in the lack of statistically significant association between the exposure and outcome variables analyzed.

Conclusion

The prevalence of intestinal and soil-transmitted helminth infections among children residing in internally displaced persons camps in Mogadishu Somalia remained high in both Deyniile and Kahda IDPs, although the intensity was light. This implies that despite the success of mass drug administration campaigns in reducing the prevalence of helminth infection, considerable sustained efforts are still needed on strengthening health systems, enhanced national and regional surveillance as well as addressing environmental and social determinants in order to achieve the morbidity elimination target. Therefore, continued mass drug administration, awareness creation and monitoring of the deworming process should be undertaken to accelerate the elimination of these important public health problems in the country.

Data availability

All data generated or analysed during this study are included in this published article.

Received: 18 November 2024; Accepted: 6 March 2025

Published online: 12 April 2025

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Author contributions

B.G., N.I.D., A.O.S., A.A.H., and I.A.M.A performed the research including sample collection and laboratory analysis. Y.U., J.H.M., and M.H.A analyzed the data. B.G., H.A.A., J.H., and F.A.H.O designed the study. B.G wrote the first draft of the paper. M.A.M., and M.M.A revised the paper. All authors read and approved the final manuscript.

Funding

None.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to N.I.D.

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