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Research Paper

Use of rivers' water, inadequate hygiene, and sanitation as exposure of internally displaced persons (IDPs) to urogenital schistosomiasis and soil-transmitted helminthiasis in Jalingo Local Government Area (LGA), Taraba State, Nigeria

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ABSTRACT

Water- and soil-transmitted helminthiasis in relation to socio-demographic status and risk factors of internally displaced persons in Jalingo Local Government Area (LGA) were determined. The nutritional status was also studied among infected individuals. Urine filtration and Kato-Katz techniques were used to examine urine and faecal samples, respectively. Urogenital schistosomiasis infection was found at a moderate level of 52 (17.6%), whereas ascariasis and hookworm infection were 48 (16.3%) and 8 (2.7%), respectively. Participants in Jauro Gbadi camp as well as the age group (41–50) years significantly had the highest infection with hookworm, 8 (8.2%) ($\chi^2 = 16.70$; $p = 0.000$) and 2 (11.7%)($\chi^2 = 17.59$, $p = 0.003$), respectively. Farmers were significantly infected with urogenital schistosomiasis (20.1%) ($\chi^2 = 14.03$; $p = 0.043$). Fishing in rivers exposed individuals to urogenital schistosomiasis with an adjusted odds ratio (aOR) = 8.60 (95% CI: 0.86–85.52; $p = 0.046$). The lack of hygienic measures exposed individuals who 'don't wash their hands before eating' to soil-transmitted helminthiasis with an aOR = 4.13 (95% CI: 0.77–21.99; $p = 0.045$). In sanitation, individuals who 'don't use pit latrines and do use the bush for defaecating' were exposed to soil-transmitted helminthiasis with an aOR = 2.14 (95% CI: 1.30–3.52; $p = 0.002$). Farmers were infected with urogenital schistosomiasis. Participants in the Jauro Gbadi camp and individuals within the age group (41–50) years had high hookworm infection. Use of river water, inappropriate hygiene, and sanitation exposed individuals to infection.

Key words: displaced, helminthiasis, internally, persons, urogenital

HIGHLIGHTS

- A first investigative study of urogenital schistosomiasis and soil-transmitted helminthiasis among internally displaced persons using river and pond water in Jalingo Local Government Area, Taraba State, Nigeria.
- Fishing and bathing activities in rivers exposed internally displaced persons to urogenital schistosomiasis.
- Unwashed hands before eating, and after defaecation as well as defaecating in the open exposed internally displaced persons to soil-transmitted helminthiasis.

INTRODUCTION

In Sub-Saharan Africa, ethnic, tribal, traditional, and religious crises were observed in communities causing the dismantlement of village inhabitants to migrate as internally displaced persons. The displacement of such individuals made new settlements as living camps to allow their survival in life. In such areas, unsafe and insufficient potable water, inadequate sanitation and hygiene were encountered among such individuals as they came from rural areas. In such environments, there are usually significant public health issues from water and nutrition thereby exposing them to water- and soil-transmitted helminthiasis (Prüss-Ustün *et al.* 2019). Water- and soil-transmitted helminthiasis had long been recognised as human infections of significant public health importance, especially in the tropics and sub-tropics. They are usually more common in children with serious effects on their nutritional status, physical development, and fitness (WHO 2022).

Schistosomiasis and soil-transmitted helminthiasis are the most common parasitic infections reported worldwide among neglected tropical diseases (Mrimi *et al.* 2022).

In Sub-Saharan Africa, urogenital schistosomiasis is found in rural and urban communities with either low or high infection. The vast majority of cases occur mostly among the poor and marginalised inhabitants (Abou-Zeid *et al.* 2012; Sacolo-Gwebu *et al.* 2019; Houmsou *et al.* 2021; Opara *et al.* 2021). Meanwhile, soil-transmitted helminthiasis causes similar health issues among the poor. Poverty, illiteracy, poor hygiene, lack of access to potable water, and a hot humid tropical climate are the factors associated with such parasitic infections (Mehraj *et al.* 2008).

In Nigeria, the communal conflicts in the present and past years have forced over a million people to flee from their homes. This has resulted in an unprecedented humanitarian crisis in the northeastern part of the country and the Lake Chad region (Norwegian Refugees Council 2015). Furthermore, inter-communal clashes resulting from ethnoreligious disputes, and tensions between Fulani herdsmen and farmers have resulted in over 700,000 people being displaced from the Middle Belt region of Nigeria (Norwegian Refugees Council 2015).

Internal displacement seriously affected the health and well-being of the migrated individuals. These issues promoted communicable diseases with affecting factors such as overcrowding, environmental degradation, poverty, the inadequacy of potable water, poor sanitation, and waste management. These conditions are further compounded by the absence of shelter, food shortages, and poor access to healthcare (Guerrier *et al.* 2009).

The issue of insecurity in the northeast of Nigeria has created a displacement of a large number of people from towns and villages to live in refugee camps. Jalingo Local Government Area (LGA), the capital of Taraba State, Nigeria has encountered the movement of the rural population during their ethnoreligious disputes. In such a situation, most of those internally displaced people had health issues due to poor management of food served, inadequate potable water supply, and poor sanitation. Several studies on water- and soil-transmitted helminthiasis in Nigeria have focused on school-aged children with little or no information on internally displaced persons. The study was conducted to determine urogenital schistosomiasis and soil-transmitted helminthiasis as well as predisposing risk factors of internally displaced persons within three camps established by the Taraba State government in Jalingo LGA. The study equally determined the effect of urogenital and soil-transmitted helminthiasis on the nutritional status of the individuals.

MATERIALS AND METHODS

Study area

Jalingo LGA is the capital city of Taraba State, Nigeria. Its geographical position is roughly located between the latitude of 8°47′ to 9°01′N and longitude of 11°09′ to 11°30′E. It is bounded to the north by Lau LGA, to the east by Yorro LGA, and to the south and west by Ardo-Kola LGA. It has a total land area of about 195 km^2. Jalingo LGA has a population of 139,845 people according to the 2006 population census (National Population Commission (NPC) 2006). The study sites surveyed were three out of the eight camps established by the Taraba State government in the Jalingo metropolis. The sites were the unused infrastructure of primary health care Gullum (8°57′N; 11°19′E), Howai Primary School Camp (08°57′N; 11°22′E), and Government Primary School Jauro Gbadi (8°55′N; 11°21′E).

Ethical clearance

Ethical approval was obtained from the Department of Health, Jalingo LGA, Taraba State in June 2021. The consent for the study was sought from chairmen of various camps and each enrolled internally displaced person signed a copy of the consent form. The field study started in July 2021 and ended in August 2021.

Questionnaire survey

A questionnaire was administered to each individual to get information on their socio-demographic and socio-economic attributes. Each participant aged from 1 to >50 years was issued a questionnaire to have information on their behavioural attitudes. The attitudes of participants were based on their hygienic and sanitation measures as well as activities in rivers/ponds/streams. The activities reported were fishing, swimming, bathing, and fishing, washing clothes and utensils in water bodies. The hygienic attitudes were based on their toiletries issues and washing of consumable fruits. Sanitation was based on the use and visit to refuse dumps. Research officials had individual verbal interviews mostly in '*Hausa*' a local language with each participant. The answers from each participant were transcribed into English to easily fill in the questionnaires.

A research official also translated the English language into '*Hausa*' for each enrolled child or children below 10 years whose parents/guardians could not communicate in the English language to interact and fill in a questionnaire.

Sample size and collection

The sample size of enrolled internally displaced persons for the study was calculated from the formula:

$$N = \frac{Z^2 \cdot p(1-p)}{d^2}$$

here $Z^2 = 1.96$, for two tails; $p = 50\%$, estimated as the prevalence of urogenital and soil-transmitted helminthiasis of inhabitants of the three camps for the study; $d^2 = 0.0025$, precision (margin error, which is 10% of the estimated prevalence).

The internally displaced persons were educated and instructed on the significance of the study a day before the collection of faecal and urine samples. Two well-labelled sterile bottles were given a day ahead to each participant to collect 20 mL of urine and 3 g of faeces. Each participant was instructed to give early morning faeces. Urine samples were collected concomitantly between 10:00 am and 2:00 pm from each enrolled individual. The sterile bottles were labelled and had identification numbers, age, and sex. Samples were preserved and taken to the laboratory of Biological Sciences, Taraba State University, Jalingo for examination using Kato-Katz and filtration techniques for faeces and urogenital schistosomiasis, respectively.

Exclusion and inclusion of internally displaced persons from various camps in Jalingo LGA, Taraba State, Nigeria

From the calculation, a total of 384 internally displaced persons were enrolled from the three camps. Circumstances like a sudden illness, unwillingness, and non-residence within the camp excluded individuals from Gullum ($n = 9$), Howai ($n = 6$), and Jauro Gbadi ($n = 9$). Three hundred and sixty ($n = 360$) internally displaced persons were enrolled in the study from the three camps. In partition to the various camps, we enrolled from Gullum ($n = 128$), Howai ($n = 114$), and Jauro Gbadi ($n = 118$). In Gullum, individuals were excluded for their non-conformity of residence in the camp ($n = 17$) and illness ($n = 12$). At Howai, nine ($n = 9$) were excluded from non-conformity of their residence within the camp and illnesses ($n = 7$). In Jauro Gbadi camp, individuals were excluded for non-conformity in residence ($n = 6$) and illness ($n = 15$). Finally, the study enrolled 99 ($n = 99$) in Gullum, 98 ($n = 98$) in Howai, and 97 ($n = 97$) in Jauro Gbadi camps (Figure 1). Each enrolled individual subsequently gave a sample of stool and urine for laboratory analysis.

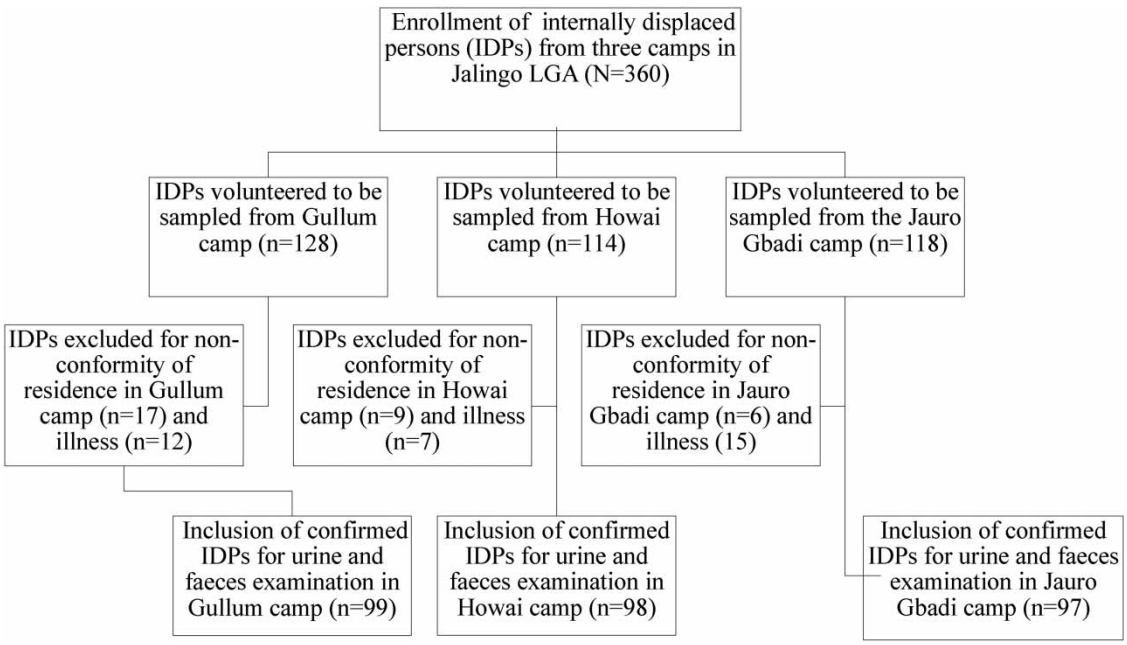

Figure 1 | Exclusion and inclusion of internally displaced persons from various camps into urine and faecal examinations.

Laboratory examination

The stools and urine samples were macroscopically examined for the physical appearance of colour, consistency, softness/form, presence of blood/mucus, particles, and whether adult worms are present or not.

Analysis of faecal samples

The consistency of each stool sample was classified according to the Bristol stool chart (Lewis & Heaton 1997). Diarrhoeic stool samples were not included in the study. A gram of stool was placed on the slide after careful removal of the kit template. Kato-Katz kits (Sterlitech Corporation, Kent, USA) were used for technical laboratory analysis for faeces (Katz *et al.* 1972).

Urine filtration technique

Filtration, known as the most standard technique for urogenital schistosomiasis, was used to process urine samples. Syringes of 10 mL were used to get urine samples. Each urine sample was filtered through a polycarbonate membrane filter (12.0 μm porosity) within a Swinney polypropylene holder (13 mm diameter) (Sterlitech Corporation, Kent, USA). Urine samples were reported as 0 eggs/10 mL of urine (not infected), 1–49 eggs/10 mL of urine (light infection), and >50 eggs/10 mL of urine (heavy infection) using the WHO standard (WHO 2002).

Determination of nutritional status of internally displaced persons in Jalingo LGA, Taraba State

The nutritional status was determined among the internally displaced persons by calculating the body mass index (BMI) of each enrolled individual. The BMI was cross-checked and interpreted as the BMI-for-age percentiles for 2–20 years (Centers for Diseases Control and Prevention (CDC) 2020). It was evaluated as undernutrition if it was less than the 5th percentile, normal if it was between the 5th percentile to less than the 85th percentile, overweight if it was between 85th to less than the 95th percentile, and obese if it was equal to or greater than the 95th percentile. The technique was used to assess the size and growth patterns of children and teens. For an adult, it was calculated as BMI = mass index in kg/(height in m)^2.

Data analysis

Collated data were entered into Microsoft Excel version 2016. IBM SPSS version 26 imported and analysed data for descriptive and inferential methods. The association between socio-demographic variables of internally displaced persons and infections was determined using chi-square (χ^2). Multivariate logistic regression analysed behavioural attitudes of internally displaced persons towards urogenital schistosomiasis as well as hygienic and sanitation measures before and after defaecation towards soil-transmitted helminthiasis. Nutritional status in infected and non-infected participants was represented using a graph. Probabilities were considered significant at $p \leq 0.05$.

RESULTS

Description of inhabitants of internally displaced person camps in Jalingo LGA, Taraba State, Nigeria

The individuals involved were as follows: 99 (33.7%) from the Gullum camp, 98 (33.3%) from the Howai camp, and 97 (33.0%) from the Jauro Gbadi camp. Females were 164 (55.8%) and males 130 (44.2%), whereas the age group of 1–10 years and 11–20 years had the higher participation, respectively, with 101 (34.4%) and 105 (35.7%). Participants with no formal education were 117 (39.8%), whereas participants with tertiary education were the least, at 17 (5.8%). With regards to occupation, farming had 221 (77.9%) while non-farming had 65 (22.1%). The helminth contamination through water was *Schistosoma haematobium*, 52 (17.7%) whereas soil-transmitted helminths were *Ascaris lumbricoides*, 48 (16.3%) and hookworm, 8 (2.7%) (Table 1).

Water- and soil-transmitted helminthiasis in internally displaced persons in Jalingo LGA, Taraba State

Table 2 shows water- and soil-transmitted helminthiasis in relation to the socio-demographic status of internally displaced persons in Jalingo LGA, Taraba State, Nigeria. The study reported that the water-transmitted helminth *S. haematobium* had an infection of 52 (17.6%). Soil-transmitted helminths *A. lumbricoides* and hookworm, respectively, had an infection of 48 (16.3%) and 8 (2.7%). From various camps, soil-transmitted helminthiasis showed that Jauro Gbadi camp had significantly higher hookworm infection, 8 (8.2%), than Gullum and Howai camps, respectively, with 0 (0.0%) ($\chi^2 = 16.70$; $p = 0.000$). Likewise, hookworm infection was significantly higher, 2 (11.7%) in the age group of (41–50) years, whereas the age group (1–10) years and >50 years, respectively, had no infection, 0 (0.0%) ($\chi^2 = 17.59$; $p = 0.003$). In occupation,

Table 1 | Description of internally displaced person camps in Jalingo LGA, Taraba State, Nigeria

Variables	Number ($N = 294$), (%)
Location	
Gullum	99 (33.7)
Jauro Gbadi	97 (33.0)
Howai	98 (33.3)
Sex	
Male	130 (44.2)
Female	164 (55.8)
Age (years)	
1–10	101 (34.4)
11–20	105 (35.7)
21–30	23 (7.8)
31–40	33 (11.6)
41–50	17 (5.8)
> 50	14 (4.8)
Education	
No formal	117 (39.8)
Primary school	76 (25.9)
Secondary school	84 (28.6)
Tertiary school	17 (5.8)
Occupation	
Farming	221 (77.9)
Non-farming	65 (22.1)
Infection	
Ascaris lumbricoides	48 (16.3)
Hookworm	8 (2.7)
Schistosoma haematobium	52 (17.7)

the water-transmitted helminth *S. haematobium* infection was significantly higher among farmers, 46 (20.8%), than non-farmers, 6 (9.2%) ($\chi^2 = 14.09$; $p = 0.043$).

The behavioural attitudes of internally displaced persons towards river and pond water significantly exposed them to *S. haematobium* through fishing with an adjusted odds ratio (aOR) = 8.60 (95% CI: 0.86–85.52, $p = 0.046$) and bathing and fishing, aOR = 0.29 (95% CI: 0.10–0.83, $p = 0.021$). For hygienic measures after defaecation, individuals who 'don't wash hands before eating' and those who 'don't wash hands after defaecation' were, respectively, more exposed to soil-transmitted helminthiasis with aOR = 4.13 (95% CI: 0.77–21.99, $p = 0.045$) and aOR = 0.98 (95% CI: 0.14–6.51; $p = 0.007$). Those who 'don't use pit latrines and do use the bush for defaecation' were more exposed to soil-transmitted helminthiasis with an aOR = 2.14 (95% CI: 1.30–13.5; $p = 0.002$) (Table 3).

Infection with regard to the nutritional status of internally displaced persons in Jalingo LGA, Taraba State, Nigeria

The undernourished internally displaced persons had higher infections with *A. lumbricoides* (33.3%) and *S. haematobium* (18.6%), whereas hookworm infection was 6.0% among those on normal nutritional status (Figure 2).

DISCUSSION

Population either in rural or urban areas has been affected by conflict or ethnoreligious issues, exposing them to malicious health concerns. In Sub-Saharan Africa, they are mostly exposed to urine and faecal parasitic diseases through contaminated

Table 2 | Water- and soil-transmitted helminthiasis in relation to camps and socio-demographic status of internally displaced persons in Jalingo LGA, Taraba State, Nigeria

		Water- and soil-transmitted helminthiasis infection (%)					
Variables	**Num. Exam**	***S. haematobium***		***A. lumbricoides***		**Hookworm**	
Overall	294	52 (17.6)	χ^2	48 (16.3)	χ^2	8 (2.7)	χ^2
IDPs' camps			3.75		1.14		16.70*
Gullum	99	13 (13.1)		13 (13.1)		0 (0.0)	
Jauro Gbadi	97	16 (16.4)		17 (17.5)		8 (8.2)	
Howai	98	23 (23.4)		18 (18.3)		0 (0.0)	
Sex			0.84		0.61		1.23
Male	130	20 (15.3)		22 (16.9)		2 (1.5)	
Female	164	32 (19.5)		26 (15.8)		6 (3.6)	
Age (years)			9.87		7.01		17.59*
1–10	101	18 (17.8)		21 (20.7)		0 (0.0)	
11–20	105	19 (18.0)		12 (11.4)		1 (0.9)	
21–30	23	8 (34.7)		5 (21.7)		2 (8.6)	
31–40	34	3 (8.8)		7 (20.5)		3 (8.8)	
41–50	17	4 (23.5)		3 (17.6)		2 (11.7)	
> 50	14	0 (0.0)		0 (0.0)		0 (0.0)	
Education			3.37		3.92		5.94
No formal	117	18 (15.3)		22 (18.8)		2 (1.7)	
Primary	76	11 (14.4)		13 (17.1)		5 (6.5)	
Secondary	84	18 (21.4)		13 (15.4)		1 (1.1)	
Tertiary	17	5 (29.4)		0 (0.0)		0 (0.0)	
Occupation			14.09*		0.15		2.23
Farmer	221	46 (20.8)		38 (17.1)		8 (3.6)	
Non-farmer	65	6 (9.2)		10 (15.3)		0 (0.0)	

*Significant at $p \leq 0.05$.

water, poor hygiene, and poor sanitation. Water- and soil-transmitted helminthiasis have been reported in infants and adults in Nigeria and Sub-Saharan Africa as a great public health concern (Nute *et al.* 2018; Sacolo-Gwebu *et al.* 2019; Ikpe *et al.* 2020; Opara *et al.* 2021; Mushi *et al.* 2022). In this study, the infections have been found on moderate levels for urogenital schistosomiasis 52 (17.6%) and low levels for ascariasis 48 (16.3%), and hookworm infection 8 (2.7%).

Despite the moderate infection of urogenital schistosomiasis reported in this study, farmers remain significantly affected by it. Recently, urogenital schistosomiasis has been found among rural inhabitants mostly involved in river and pond water for their daily agricultural activities and recreation (Houmsou *et al.* 2021). In this study, the inhabitants of the camps were involved in fishing the catfish *Clarias gariepinus* as well as bathing and swimming in rivers or ponds.

The infection with *A. lumbricoides* was not significant at the socio-demographic level of internally displaced persons. This shows a similar poor attitude at their hygienic and sanitation level.

Hookworm infection was significant among internally displaced persons inhabiting the Jauro Gbadi camp. The infection was in a transmissible area of the camp because of the sandy soil structure. The climate around the river in the place was less hot and it would have facilitated the growth and maturity of the hookworm larvae. The age groups from 11 to 50 years were significantly affected by hookworm infection. The major issue observed during the interviews of the younger children and interaction with adults was the lack of funds to buy shoes, thereby exposing themselves to infection. The behaviours of not wearing shoes during their movement, lack of hygiene after defaecation, and lack of sanitation around their environment

Table 3 | Multivariate analysis of behavioural attitudes of internally displaced persons to river and pond water and their hygienic and sanitation measures after defaecation as predictors to urogenital schistosomiasis and soil-transmitted helminthiasis, respectively, in various camps of Jalingo LGA, Taraba State, Nigeria

Factors	Infection (%)	aOR (95% CI)	*p*
Behavioral attitudes to river water for *S. haematobium*			
• Distance from ponds		1.31 (0.76–2.24)	0.325
< 500 m	45 (15.3)		
> 500 m	7 (2.3)		
• Bathing in river		0.51 (0.08–3.18)	0.475
No	27 (19.6)		
Yes	25 (16.0)		
• Fishing in river		8.60 (0.86–85.52)	0.046*
No	1 (6.7)		
Yes	51 (18.3)		
• Bathing and fishing in ponds		0.29 (0.10–0.83)	0.021*
No	3 (8.1)		
Yes	48 (18.6)		
Hygienic and sanitation measures towards soil-transmitted helminthiasis after defaecation			
• Don't wash your hands before eating		4.13 (0.77–21.99)	0.045*
No	1 (3.1)		
Yes	55 (20.3)		0.007*
• Don't wash your hands after defaecation		0.98 (0.14–6.51)	0.134
No	8 (12.5)		
Yes	48 (20.1)		
• Don't wash fruits before consumption		3.39 (0.68–16.78)	
No	12 (4.0)		
Yes	44 (15.0)		
• Don't use a pit latrine and do use a bush for defaecation		2.14 (1.30–13.52)	0.002*
No	3 (1.0)		
Yes	53 (18.1)		
• Do use bore-hole and well as a drinking water source		0.91 (0.67–1.23)	0.554
No	13 (4.0)		
Yes	40 (13.6)		

Note: aOR, adjusted odd ratio; CI, confidence interval.
*Significant at $p \leq 0.05$.

was also observed among the internally displaced children. A study conducted in China reported significant infection among similar age groups (Bethony *et al.* 2002).

The attitude of searching and fishing the catfish *C. gariepinus* exposed internally displaced persons to urogenital schistosomiasis with an aOR of 8.60 (95% CI: 0.86–85.52, $p = 0.046$). The involvement of internally displaced persons in such

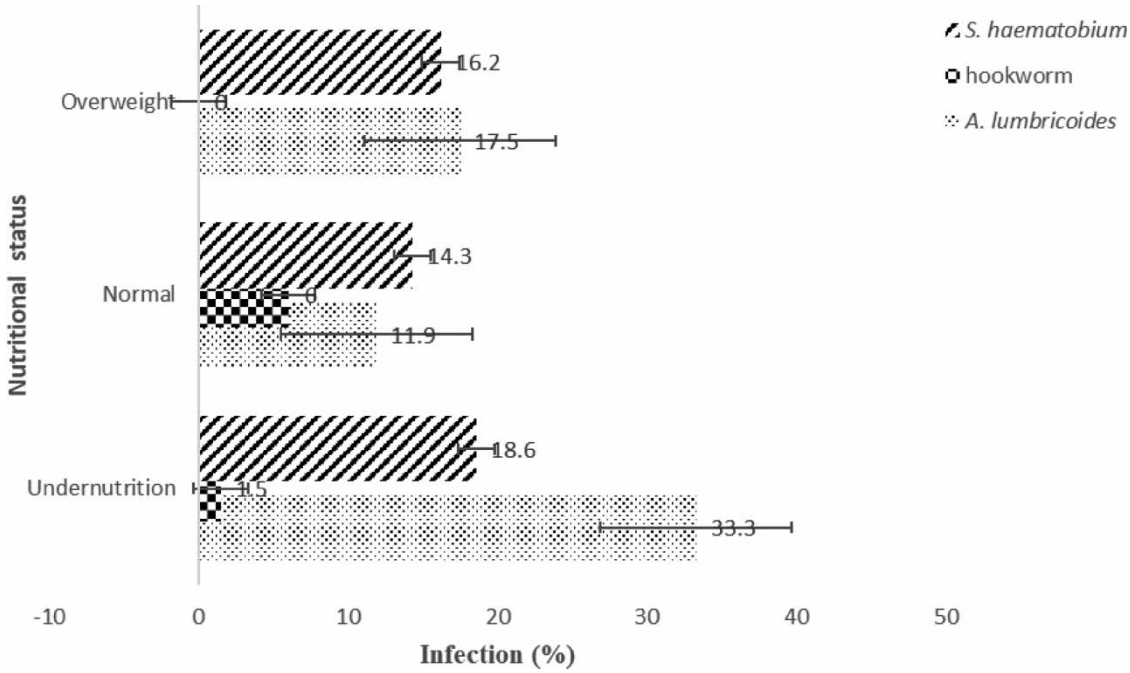

Figure 2 | *Schistosoma haematobium* and soil-transmitted helminthiasis in relation to the nutritional status of internally displaced persons in Jalingo LGA, Taraba State, Nigeria.

activities exposed most of them to such infection. Urogenital schistosomiasis has also been reported among internally displaced inhabitants of various camps in Maiduguri, Nigeria (Yauba *et al.* 2018). Inhabitants involved in such activity were also infected in four regions of Gambia (Joof *et al.* 2021) and communities of the Magba sub-division in Cameroon (Njunda *et al.* 2017).

The hygienic and sanitation attitudes of the internally displaced persons in various camps were poor. Their hygienic attitudes of not washing hands before eating and after their defaecation exposed them to soil-transmitted helminthiasis with an aOR of 4.13 (95% CI: 0.77–21.99; $p = 0.045$) and 0.98 (95% CI: 0.14–6.51; $p = 0.007$), respectively. They relocated with the same attitude adopted from their various villages as they were not educated and instructed on the hygienic measures beneficial to their health. For their sanitation, they were not defaecating in the pit latrines but were using the open environment to defaecate. Such attitudes exposed them to soil-transmitted helminthiasis with an aOR of 2.14 (95% CI: 1.30–13.52, $p = 0.002$). A similar situation has been reported in Nigeria (Fafunwa *et al.* 2017; Mogaji *et al.* 2022; Njoba *et al.* 2022), developing countries of Sub-Saharan Africa (Sacolo-Gwebu *et al.* 2019), Asia (Ercumen *et al.* 2019), and central America (Rao *et al.* 2021).

A. lumbricoides and *S. haematobium* infections have been much more prevalent among undernourished internally displaced persons. This is because in infected subjects, the nutrients have been metabolised by the parasites for their development and multiplication, thereby causing nutritional deficiencies. Frigerio *et al.* (2016) observed a similar effect of *S. haematobium* on malnutrition among school children in rural settings of northern Senegal. A portion of the development of undernutrition has been enumerated and infestation with schistosomiasis and intestinal parasites can be a serious risk among infected individuals (Tanner *et al.* 2009; Adeniran *et al.* 2017).

The limitation of this study was the refusal of most of the internally displaced persons to be enrolled in laboratory examinations. Second, the faecal and urine samples were examined once instead of three times as per WHO standards.

CONCLUSION

The study identified a medium rate of infection with *S. haematobium* as well as low infections with *A. lumbricoides* and hookworm. The farmers were significantly affected by urogenital schistosomiasis while the age group (41–50) years was highly affected by hookworm infection. The behavioural attitudes of fishing and bathing exposed more individuals to urogenital

schistosomiasis. The lack of personal hygienic attitudes such as 'don't wash hands before eating' and don't wash hands after defaecation' exposed internally displaced persons to soil-transmitted helminthiasis. The sanitation attitude of 'don't use pit latrine and do use the bush for defaecation' equally exposed internally displaced persons to soil-transmitted helminthiasis. Internally displaced persons with undernutrition had infections of *A. lumbricoides* and *S. haematobium*.

The improvement and supply of potable drinking water as well as hygienic activities should be implemented at various local camps in Taraba State and even nationally to avoid soil-transmitted helminthiasis. The washing of hands after greetings and washing of hands before and after food consumption should be instructed to internally displaced persons in various local and national camps. The washing of fruits before consumption and avoiding of defaecation in close-by bushes should be instructed to internally displaced persons in local and even national camps. The appropriate use of detergents to clean pit latrines and their environment as well as sanitation of environmental surroundings of camps are also recommended to internally displaced persons locally and nationally.

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AUTHOR CONTRIBUTIONS

W.E.B. and R.S.H. conceived the study. W.E.B., R.S.H., and L.C.G. were involved in data collection and laboratory analysis. W.E.B., R.S.H., and L.C.G.. were involved in the methodology. W.E.B. and R.S.H. acquired the TETFUND grant in 2021. R.S.H. analysed the data and drafted the article. W.E.B., R.S.H., L.C.G.., K.L.S., and E.U.A. reviewed and edited the manuscript.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Abou-Zeid, A. H. A., Abkar, T. A. & Mohamed, R. O. 2012 Schistosomiasis and soil-transmitted helminths among an adult population in a war-affected area, Southern Kordofan State, Sudan. *Parasites and Vectors* **5**, 133. https://doi.org/10.1186/1756-3305-5-133.

Adeniran, A. A., Mogaji, H. O., Aladesida, A. A., Olayiwola, I. O., Oluwole, A. S., Abe, E. M., Olabinke, D. B., Alabi, O. M. & Ekpo, U. F. 2017 Schistosomiasis, intestinal helminthiasis, and nutritional status among preschool-aged children in sub-urban communities of Abeokuta, Southwest, Nigeria. *BMC Research Notes* **10**, 637. https://doi.org/10.1186/s13104-017-2973-2.

Bethony, J., Chen, J., Lin, S., Xiao, S., Zhan, B., Li, S., Xue, H., Xing, F., Humphries, D., Yan, W., Chen, G., Foster, V., Hawdon, J. M. & Hotez, P. J. 2002 Emerging patterns of hookworm infection: influence of aging on the intensity of *Necator* infection in Hainan Province, People's republic of China. *Clinical Infectious Diseases* **35** (11), 1336–1344. doi:10.1086/344268.

Centers for Diseases Control and Prevention (CDC) 2020 *Healthy Weight*. Available from: http//www.cdc.gov/healthyweight/assessing/bmi/childrenbmi/aboutchildren_bmi.html.

Ercumen, A., Benjamin-Chung, J., Arnold, B. F., Lin, A., Hubbard, A. E., Stewart, C., Rahman, Z., Parvez, S. M., Unicomb, L., Rahman, M., Haque, R., Colford Jr, J. M. & Luby, S. P. 2019 Effects of water, sanitation, handwashing and nutritional interventions on soil-transmitted helminth infections in young children: a cluster randomized controlled trial in rural Bangladesh. *PLoS Neglected Tropical Diseases* **13** (5), e0007323. https://doi.org/10.1371/journal.pntd.0007323.

Fafunwa, T. S., Mogaji, H. O., Oluwole, A. S., Adeniran, A. A., Fagbenro, M. T., Sam-Wobo, S. O., Bada, B. S. & Ekpo, U. F. 2017 Water resource, hygienic practice, and soil- transmitted helminthiasis in some rural communities of Osun State, Nigeria. *Journal of Water Resource and Protection* **9**, 99–110. https://doi.org/10.4236/jwarp.2017.92008.

Frigerio, S., Macario, M., Iacovone, G., Dussey-Comlavi, K. J., Narcissi, P., Ndiaye, A. T., Moramarco, S., Alvaro, R., Palombi, L. & Buonomo, E. 2016 *Schistosoma haematobium* infection, health and nutritional status in school-age children in a rural setting in Northern Senegal. *Minerva Pediatrica* **68** (4), 282–287.

Guerrier, G., Zounoun, M., Delarosa, O., Defourny, I., Lacharite, M. & Brown, V. 2009 Malnutrition and mortality patterns among internally displaced and the non-displaced population living in a camp, a village or a town in Eastern Chad. *PLoS One* **4**, e8077.

Houmsou, R. S., Wama, B. E., Agere, H., Uniga, J. A., Bingbeng, J. B., Jerry, T. J., Azuaga, P., Amuta, E. U. & Kela, S. L. 2021 Integrated control of river and pond water as an exposure source to urogenital schistosomiasis of rural inhabitants in southern Taraba State, Nigeria. *Journal of Water, Sanitation, and Hygiene for Development* **11** (4), 546–557. https://doi.org/10.2166/washdev.2021.257. https://doi.org/10.1186/s12889-017-4539-6.

Ikpe, R. T., Taiwo, O. O., Edungbola, L. D., Nyamngee, A. & Amaechi, E. C. 2020 Concurrent intestinal schistosomiasis and soil-transmitted nematode infections in Primary School Children, Benue State North Central Nigeria. *Ceylon Journal of Science* **49** (3), 245–251. http://doi.org/10.4038/cjs.v49i3.7775.

Joof, E., Sanyang, A. M., Camara, Y., Sey, A. P., Baldeh, I., Jah, S. L., Ceesay, S. J., Sambou, S. M., Sanyang, S., Wade, C. M. & Sanneh, B. 2021 Prevalence and risk factors of schistosomiasis among primary school children in four selected regions of The Gambia. *PLoS Neglected Tropical Diseases* **15** (5), e0009380. https://doi.org/10.1371/journal.pntd.0009380.

Katz, N., Chaves, A. & Pellegrino, J. A. 1972 Simple device for quantitative stool thick- smear technique in Schistosomiasis mansoni. *Revista do Instituto Medecina Tropical de Sao Paulo* **14** (6), 397–400.

Lewis, S. J. & Heaton, K. W. 1997 Stool form scale as a useful guide to intestinal transit time. *Scandinavian Journal of Gastroenterology* **32**, 920–924. https://doi.org/10.3109/00365529709011203.

Mehraj, V., Hatcher, J., Akhtar, S., Rafique, G. & Beg, M. A. 2008 Prevalence and factors associated with intestinal parasitic infection among children in an urban slum of Karachi. *PLoS ONE* **3** (11), e3680. https://doi.org/10.1371/journal.pone.0003680.

Mogaji, H. O., Johnson, O. O., Adigun, A. B., Adekunle, O. N., Bankole, S., Dedeke, G. A., Bada, B. S. & Ekpo, U. F. 2022 Estimating the population at risk with soil- transmitted helminthiasis and annual drug requirements for preventive chemotherapy in Ogun State, Nigeria. *Scientific Reports* **12**, 2027. https://doi.org/10.1038/s41598-022-06012-1.

Mrimi, E. C., Palmeirim, M. S., Minja, E. G., Long, K. Z. & Keiser, J. 2022 Malnutrition, anaemia, micronutrient deficiency and parasitic infections among schoolchildren in rural Tanzania. *PLoS Neglected Tropical Diseases* **16** (3), e0010261. https://doi.org/10.1371/journal.pntd.0010261.

Mushi, V., Zacharia, A., Shao, M., Mubi, M. & Tarimo, D. 2022 Persistence of *Schistosoma haematobium* transmission among school children and its implication for the control of urogenital schistosomiasis in Lindi, Tanzania. *PLoS ONE* **17** (2), e0263929. https://doi.org/10.1371/journal.pone.0263929.

National Population Commission (NPC) 2006 *Nigeria National Census: Population Distribution by Sex, State, LGAs and Senatorial District: Census Priority Tables (Vol. 3)*. Available from: http://www.population.gov.ng/index.php/publication/140-pop-distri-by-sex-state-jgas-and-senatorialdistr-2006.

Njoba, F. C., Ekejindu, I. M., Ezeagwuna, D. A. & Nnamani, C. P. 2022 Helminthic infections among primary school children in Gboko, Benue State, Nigeria. *Current Medical Research and Practice* **12**, 13–19. doi:10.4103/cmrp.cmrp_117_21.

Njunda, A. L., Ndzi, E. N., Assob, J. C. N., Kamga, H. L. F. & Kwenti, E. T. 2017 Prevalence and factors associated with urogenital schistosomiasis among primary school children in the barrage, Magba sub-division of Cameroon. *BMC Public Health* **17**, 618.

Norwegian Refugee Council 2015 *Global Overview 2015, People Internally Displaced by Conflict and Violence*. p. 29. Norwegian Refugee Council/Internal Displacement Monitoring Centre (NRC/IDMC), Oslo/Geneva..

Nute, A. W., Endeshaw, T., Stewart, A. E. P., Eshetu, S., Bayissasse, B., Zerihun, M., Gessesse, D., Chernet, A., Chanyalew, M., Tedessse, Z., King, J. D., Emerson, P. M., Callahan, K. E. & Nash, S. D. 2018 Prevalence of soil-transmitted helminths and *Schistosoma mansoni* among a population-based sample of school-age children in Amhara region, Ethiopia. *Parasites and Vectors* **11**, 431. https://doi.org/10.1186/s13071-018-3008-0.

Opara, K. N., Eteye, U. W., Yaro, C. A., Alkazmi, L., Udoidung, N. I., Chikezie, F. M., Bassey, B. E. & El-Saber, B. G. 2021 Prevalence, risk factors, and co-infection of urogenital schistosomiasis and soil-transmitted helminthiasis among primary school children in Biase, southern Nigeria. *Journal of Parasitology Research* p. 12. ID 6618394. https://doi.org/10.1155/2021/6618394.

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, C. A., Gordon, B., Hunter, P. R., Medlicott, K. & Johnston, R. 2019 Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low and middle-income countries. *International Journal of Hygiene and Environmental Health* **222** (5), 765–777. https://doi.org/10.1016/j.ijheh.2019.05.004.

Rao, G., Blackstock, A. J., Derado, G., Cuéllar, V. M., Juliao, P., Alvarez, M., López, B., Muñoz, F., Thornton, A., Patel, J. C., Lopez, G., Rivera, J. G., Reyes, L., Arvelo, W., Lindblade, K. A. & Roy, S. L. 2021 An evaluation of water, sanitation, and hygiene status and household assets and their associations with soil-transmitted helminthiasis and reported diarrhea in Nueva Santa Rosa, Guatemala. *Journal of Water, Sanitation, and Hygiene for Development* **11** (3), 362–373. https://doi.org/10.2166/washdev.2021.160.

Sacolo-Gwebu, H., Chimbari, M. & Kalinda, C. 2019 Prevalence and risk factors of schistosomiasis and soil-transmitted helminthiases among preschool-aged children (1–5 years) in rural KwaZulu-Natal, South Africa: a cross-sectional study. *Infectious Diseases of Poverty* **8**, 47. https://doi.org/10.1186/s40249-019-0561-5.

Tanner, S., Leonard, W. R., McDade, T. W., Reyes-Garcia, V., Godoy, R. & Huanca, T. 2009 Influence of helminth infections on childhood nutritional status in lowland Bolivia. *American Journal of Human Biology* **21** (5), 651–656. https://doi.org/10.1002/ajhb.20944.

WHO 2022. Available from: www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections.

WHO 2002 *WHO Expert Committee on the Control of Schistosomiasis (2001; Geneva, Switzerland) Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis: Report of A WHO Expert Committee. WHO Technical Report Series:912*.

Yauba, S. M., Rabasa, A. I., Farouk, A. G., Elechi, H. A., Ummate, I., Ibrahim, B. A., Ibrahim, H. A., Baba, A. S., Boda, T. A. & Olowu, W. A. 2018 Urinary schistosomiasis in Boko Haram related internally displaced Nigerian children. *Saudi Journal of Kidney Diseases and Transplantation* **29** (6), 1395–1402. https://www.sjkdt.org/text.asp?2018/29/6/1395/248286.

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