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ORIGINAL RESEARCH ARTICLE

Impact of Soil-Transmitted Helminthes (STHs) on nutritional and anemia status in school-aged children in Batagarawa Local Government Area, Katsina State, Nigeria

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ABSTRACT
Malnutrition and anaemia in school-aged children, particularly in developing nations, are serious public health issues linked to Soil-transmitted helminths (STHs). To determine the prevalence and impacts of STHs on children's nutritional and anaemia status, a across-sectional study involving 320 randomly selected school-aged children aged 5 to 10 years in Batagarawa Local Government Area; Katsina State, Nigeria was conducted. Stool samples were collected and examined for the presence of STHs using the Formal-ether concentration technique. Body mass index (BMI) for age and haematocrit packed cell volume (PCV), respectively, were used to assess the nutritional and anaemia condition of the sampled children. A systematic questionnaire was used to obtain socio-demographic information. Three types of STH were identified, with an overall prevalence of 59.1%. *Ascaris lumbricoides* was more common (44.7%) than hookworm (29.1%) and *Trichuris trichiura* (2.5%). Location, soil play habits, not washing of hands after defecation, and walking barefoot were significantly associated with STHs (p<0.05). Infected children were more anaemic than the uninfected, but the difference was not statistically significant (p>0.05). Body mass index (BMI) percentile for age showed that 74.6% of the infected children were thin or under grown. Only 22.2% of the children achieve the normal growth and 3.2% were overweight. This study showed that STHs affected the children nutritional and anaemia status. Therefore, public education, deworming, and further research are encouraged to reduce the impact of STHs infection in the study area.

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Soil-Transmitted Helminthes; School-aged; Anaemia; Body mass index; Nigeria

INTRODUCTION

The world's poorest populations frequently suffer from intestinal helminth infections; which are frequently considered as the primary cause of prevalent chronic diseases (Anunobi *et al*., 2019). In developing nations, intestinal parasitism is a severe public health issue frequently disregarded (Elmonir *et al*., 2021). Communities with low environmental and personal cleanliness, inadequate nourishment, overcrowding, and favourable climatic conditions are more likely to have infections (Karshima, 2018). Children are said to have the highest risk of contracting intestinal helminths due to their unclean habits, including playing with dirt and/or handling infected objects, using unhygienic restroom practices and consuming contaminated food and water (Idowu *et al*., 2019).

Soil-transmitted helminths are a group of intestinal parasitic nematodes that cause diseases or infect humans when exposed to the infective stages of the parasite (eggs or larvae) that thrive in warm and moist soil (Mirisho, 2017). Soil-transmitted helminths are common in tropical and subtropical countries worldwide, including China, Americas, sub-Saharan Africa, and East Asia where the standard of living is low and sanitary and environmental conditions are poor (Nwankwo *et al*., 2021). Infection with soil-transmitted helminth parasites, including giant roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*) and hookworm (*Necartor americanus* and *Ancylostoma duodenale*) affect about one fourth of the world population (Ahmed and Sani 2019). According to estimates, there are 1221–1472 million people infected

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with *Ascaris lumbricoides*, 740–1300 million infected with Hookworms, and 750–1050 million people infected with *Trichuris trichiura* worldwide (Mirosho *et al*., 2017). They are all regarded as one since it is typical for a single person to have chronic infections with all of them (Adekola *et al*., 2018).
Nearly 181 million children in sub-Saharan African countries are infected with intestinal helminths due to heavy worm burden, which causes considerable morbidity and mortality (Tulu *et al.,* 2016).
Infection with soil-transmitted helminths frequently results in well-known symptoms such as malnutrition, decreased cognitive function, anaemia, diarrhoea, and gastrointestinal complications (Adekola *et al*., 2018). Due to increased metabolic rate, persistent anaemia, and diarrhoea brought on by a high worm load, soil-transmitted helminth infection significantly impacts nutritional and cognitive health, particularly in school-aged children. For assessing the nutritional status of populations, especially children in underdeveloped nations, anthropometry has evolved into a helpful instrument. Similarly, children's nutritional state is the best gauge of their overall well-being (Ajayi *et al*., 2017).
Nigeria remained the African country with the highest burden and endemicity of intestinal helminthiasis, with children residing primarily in rural and semi urban areas constituting a greater percentage (Anunobi *et al*., 2019). Several epidemiological studies among Nigerian children (Ahmed and Sani 2019; Nwankwo *et al*., 2021; Nzeukwu *et al*., 2022; Pukuma *et al*., 2022) have revealed the presence of soil-transmitted helminths with varying degrees of magnitude. Similarly, it is worth noting that Rafindadi *et al*. (2013) reported prevalence of intestinal helminth parasites in the study area and linked infection to malnutrition, with half of the infected children being underweight. Children's common practice of open defecation and poor personal hygiene; the use of human excreta in agricultural land as manure; and the study area's all-year-round favourable climatic conditions that support the growth and development of the parasites' resting stages could continue to predisposed inhabitant to infective stages and increase the prevalence of helminth parasites. As a result, providing evidence that can guide more integrated control measures is extremely important. Therefore, a follow-up study was conducted to ascertain the current prevalence, risk factors, and impact of soil transmitted helminthiasis among school children in Batagarawa Local Government Area of Katsina state, Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted in Batagarawa local government area of Katsina state, Nigeria. The local government was founded in 1991, and Hausa people make up most of its population. It is located between latitude 12° 54' N and longitude 7° 37' E. According to the 2006 population census, it has an area of 433km² (167 sq miles) and a population of 184,575.

Sample size determination

The prevalence of gastrointestinal helminth infection (24%) in primary school children of Batagarawa Lacal Government Area, Katsina State, Nigeria (Rafindadi *et al*., 2013) was considered. The sample size was estimated using the formula below (Edogiawerie *et al*., 2016):

$$n = \frac{Z^2 PQ}{d^2}$$

where:
n = sample size
Z = standard score (1.96)
P = prevalence previously reported from related work
Q = 1-p
d = allowable error (0.05)

$$\frac{(1.96)^2 \times 0.24(1-0.24)}{(0.05)^2}$$

$$\frac{3.8416 \times 0.24 \times 0.76}{0.0025}$$

$$\frac{0.70070784}{0.0025}$$

$n \approx 280$

However, 350 children were selected to take care of dropouts and the possibility of non-participation by some subjects.

Samples collection

A cross-sectional study of 320 randomly chosen primary school students in the Batagarawa Local Government, aged 5 to 10 years was conducted. Samples from students who varied in important interest-related characteristics like age, sex and location were obtained. The students were given a structured questionnaire to obtain socio-demographic information, which they filled with the kind assistance of the school teachers. Each student who signed up was given an identity number that matched to the questionnaire and sample bottle. Each student was instructed on how to collect stool sample to prevent contamination. Stool samples were collected in sterile screw cap container. Each student had five (5) ml of blood drawn, and then placed into an EDTA bottle labelled and kept in a thermo box by medical workers. Each child's weight was measures using an electronic digital balance with a preset weight of 0.1kilogram (kg). The age of each sampled student was recorded in accordance with height, which was subsequently measured using a height pole put on the wall (Manir *et al*., 2017; Ihejirika *et al*. 2019). All samples were taken to the Laboratory of Biology department, Umaru Musa Yar'adua University for further examination.

Ethical Approval

Ethical permission with reference number MOH/ADM/SUB/1152/1/211 was obtained from the Katsina State ministry of health.

Detection of the Helminth in the Stool Samples

Stool samples were examined for intestinal helminth using the Formal-Ether Sedimentation Technique described by Cheesbrough (2006). Two grams (2g) of faeces sample were placed in a test tube with 10ml of normal saline solution, which was then filtered through two layers of gauze into a centrifuge tube. At 2000 rpm, the solution was centrifuged and the supernatant was discarded. Ten (10ml) of formaldehyde solution was added to the sediment, mixed, and left to stand for five minutes. Then, 3ml of ether was added and vigorously shaken for 1 minute. The solution was then centrifuged roughly for five minutes. The supernatant was discarded, and the residue was placed on a slide, covered with a cover slip, and examined under a microscope at a magnification of x10. Lugol's iodine was used to help identify the helminth eggs/ova recovered with the assistance of a parasitologist as described by Cheesbrough (2006).

Determination of parked cell volume

Blood samples from the EDTA bottle were placed in capillary tubes after being labelled. The capillary tips were cleaned with cotton wool, sealed, and placed inside the hematocrit centrifuge. Then, it was centrifuged 1200 revolutions per minute. Hematocrit reader was used to determine the parked cell volume (Cheesbrough, 2006).

Anthropometry assessment

The nutritional status of each child was determined using measurements of their height, weight, age and sex. Each child's growth status was calculated using Anthro-Plus software. The children's nutritional status was determined based on the Z score data. Using body mass index (BMI) for age, the nutritional indicators were classified as thinness, normal growth, and overweight. A child with a growth status in the 15th percentile or below is considered to have thin or poor growth whereas those in the 50th percentile have normal growth and those within the 75th percentile and more are considered overweight (WHO, 2009).

Statistical analysis

Data collected for this study were entered into SPSS (Statistical Package for Social Sciences) software version 16.0 for statistical analysis. The frequencies and percentages of the variables evaluated were calculated using descriptive statistics. Chi-square statistics was used to examine the association between the prevalence of STHs and possible risk factors. Statistics were considered significant at $p \leq 0.05$.

RESULTS

In total, 320 primary school children of Batagarawa Local Government participated voluntarily in this study (Table 1). This included 181(56.6%) children in rural and 139(43.4%) children in semi-urban settings. Males made up the majority of the children 213(66.6%). Most of the children (87.8%) were within the age group of 8-10 years. Further investigation revealed that the majority of the children (39.4%) utilize tap water for drinking and domestic purposes, whereas 57.5% of the children typically consume unwashed fruits and vegetables. The usage of pit latrines was made convenient by 71.3% of the children.

Table 1: General characteristics of the study population (n=320)

Variables	F	(%)
Residence		
Semi-urban	139	43.4
Rural	181	56.6
Gender:		
Male	213	66.6
Female	107	33.4
Age group:		
5-7	39	12.2
8-10	281	87.8
Source of water		
Well	109	34
River	85	26.6
Tap/Borehole	126	39.4
Consumption of fresh Vegetables and Fruits		
Washed	136	42.5
Unwashed	184	57.5
Toilet Facilities available		
Pit Latrine	228	71.2
Bush Latrine	61	19.1
Others	31	9.7
Playing with Soil		
Yes	226	70.6
No	94	29.4
Washing of hands after defecation		
Yes	264	82.5
No	56	17.5
Walking barefoot		
Yes	48	15
No	272	85

Key: F = frequency, % = percentage

In addition, 70.6% of the children plays with soil, 82.5% wash hands after defecation and 15% walk barefoot. The analysis of the stool samples showed that more than half of the children (59.1%) were infected with at least one species of soil-transmitted helminths (Figure 1). *A. lumbricoides* was found to be present in roughly half (44.7%) of the infected children, hookworm was found to be present in 29.1% of the children, and *T. trichiura* was found in 2.5% of the children (Table 2). The prevalence of mixed infections with hookworm plus *T. trichuira* and *T. trichuira* with *A. lumbricoides* was 1.3% and 1.9% respectively, while mixed infections with *A. lumbricoides* and hookworm had the highest rate (14.1%). Additionally, *A. lumbricoides*, *T. trichuira* and hookworm infections occurred at 1.3%.

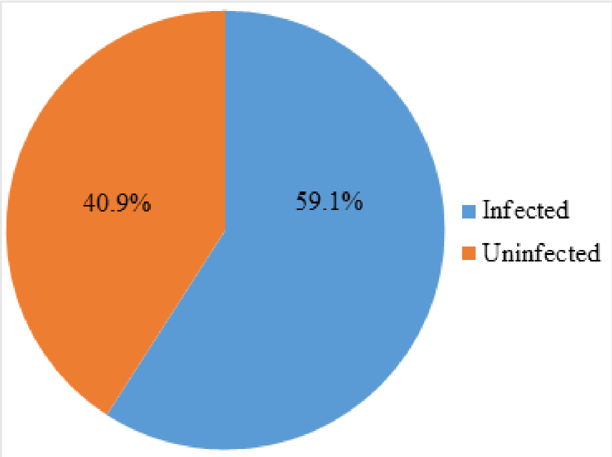

Figure 1: Overall prevalence of parasitic infection in the study area

Table 2: Identity and distribution of parasites species isolated (N=320

Parasites	No. Infected	(%)
Single Infection		
A. lumbricoides	143	44.7
Hookworms	93	29.1
T. trichuira	8	2.5
Mixed Infection		
A. lumbricoides + Hookworms	45	14.1
Hookworms + T. trichuira	4	1.3
T. trichuira+ A. lumbricoides	6	1.9
A. lumbricoides + Hookworms + T. trichuira	4	1.3

Table 3: Soil-transmitted helminths infection and potential risk factors among children in the study area Government (N=320)

Variable	No. of Positives (%)	No. of Negatives (%)	P-value
Residence			
Rural	118 (65.2)	63 (34.8)	0.02
Semi-urban	71 (51.1)	68 (48.9)	
Gender			
Males	127 (59.6)	86 (40.4)	0.654
Females	61 (57.1)	46 (42.9)	
Age group			
5-7	23 (59.0)	16 (41.0)	0.856
8-10	166 (59.1)	115 (40.9)	
Source of water			
Well	56 (51.4)	53 (48.6)	0.668
River	74 (87.1)	11 (12.9)	
Tap/Borehole	59 (46.8)	67(53.2)	
Consumption of fresh Vegetables and Fruits			
Washed	67 (49.3)	69 (50.7)	0.002
Unwashed	122 (66.3)	62 (33.7)	
Toilet Facilities available			
Pit Latrine	138 (60.5)	90 (39.5)	0.118
Open Space	39 (63.9)	22 (36.2)	
Others	12 (38.7)	19 (61.3)	
Playing with soil			
Yes	151 (66.8)	75 (33.2)	0.003
No	38 (40.4)	56 (59.6)	
Washing of hands after defecation			
Yes	148 (56.1)	116 (43.9)	0.001
No	41 (73.3)	15 (26.8)	
Walking barefoot			
Yes	37 (77.1)	11 (22.9)	0.000
No	152 (55.2)	120 (44.9)	

In terms of socio-demographic factors, STH prevalence was significantly lower ($p<0.05$) among children in semi-urban areas (51.1%) compared to rural areas (65.2%). Children in the age group 8-10years had slightly higher prevalence rate (59.1%) than children in the age group 5-7 years with a prevalence rate of 59.0%. Nevertheless, there was no significant variation ($p>0.05$) in infection rates between the various age groups. According to the results, males had a somewhat higher prevalence rate (59.6%) than females (57.1). Children who obtained their drinking water from a river had the highest prevalence of soil-transmitted helminths (87.1%), followed by children who obtained it from well (51.4%). The least prevalent group of children drank water from the taps (46.7%). The highest prevalence of STH infections (63.9%) was obtained among children using open spaces for convenience than children using pit latrines (60.5%). After defecating, children who washed their hands had lower rate (56.06%) than those who did not (73.21%). STH infections were strongly linked ($p<0.05$) with behaviours such as playing with soil, not washing of hands after defecation and walking barefoot (Table 3). The finding revealed that children infected with STH were more anaemic 58/189(30.7%) than the uninfected ones 25/131(19.8) (Table 4). Overall prevalence rates for thinness, normal growth and overweight were determined to be 70.9%, 21.9% and 7.2% respectively. Among the 189 infected children, 141(74.6%) were thin growth, 42(22.2%) had normal growth and 6(3.2%) had overweight. Out of 131 uninfected pupils, 86(65.6%) were thin, 28(21.4%) had normal growth and 17(13.0%) had overweight. Chi-square analysis of infected and uninfected children showed a significant difference ($p>0.05$) (Table 5)

Table 4: Anaemia prevalence among infected and uninfected children in the study area (n=320

		Anaemia status	
Infection status	**No. examined**	**No. anaemic**	**No. non-anaemic**
Infected	189	58 (30.7)	131 (69.3)
Uninfected	131	25 (19.8)	106 (80.2)
Total	**320**	**83 (25.9)**	**237 (74.1)**

Table 5: Mean anthropometric characteristics of infected and uninfected children in the study area (n=320)

Infection status	**No. examined**	**No. with grade 3 thinness (15th percentile)**	**No. with nomal growth (50th percentile)**	**No. with overweight (85th percentile)**
Infected	189	141 (74.6)	42 (22.2)	6 (3.2)
Un-infected	131	86 (65.6)	28 (21.4)	17 (13.0)
Total	**320**	**227 (70.9)**	**70 (21.9)**	**23 (7.2)**

DISCUSSION

The prevalence of intestinal helminth infections varies among populations and is influenced by various variables, most notably environmental, parasite, and host factors (Wekesa *et al*., 2014). The current investigation revealed that at least one species of soil-transmitted helminths was present in 59.1% of the study population. The prevalence obtained is higher than many findings made previously among school-aged children such as the works of Nwankwo *et al.* (2021) who discovered a prevalence of 44.2% in Anambra State, Nigeria; Adekola *et al.* (2018) who discovered a prevalence rate of 31.3% from Southwestern Nigeria; Yarinbab and Darcha (2019) who discovered a prevalence of 38.3% among Primary School Children in Kerewo Town, Gena Bossa Woreda, Ethiopia, and Usang *et al.* (2020) who discovered 18.5% in Cross River State, Nigeria; It is however, less than the prevalence rates discovered in a number of other studies, including 63.49% reported by Manir *et al.* (2017) among school-aged children in Dutsinma Area, Katsina State, Nigeria, 69.9% reported by Idowu *et al.* (2022) in Ogun State, Nigeria. The outcome is comparable to STH infection prevalence rates of 60.3% reported by Ahemed and Sani (2019) among pre-school children in Katsina metropolis, Katsina state, Nigeria. The disparity in prevalence rates reported by various authors may result from the differences in geographical settings, sample size, or methods employed to analyze stool samples. The types of helminth parasites namely; *A. lumbriocoides*, Hookworm and *T. trichiura* documented in this study are comparable to those reported in studies of the same kind conducted in Nigerian (Ahemed and Sani, 2019; Omotola and Ofoezie, 2019; Idowu *et al*., 2019; Idowu *et al*., 2022) and other sub-Saharan African nations, including Ethopia (Yarinbab and Darcha 2019), Kenya (Masaku *et al*., 2014), and Cameroon (Cho *et al*., 2021). The relative greater prevalence (44.7%) of *A. lumbricoides* than any other STHs identified in the investigation is not surprising since Nwankwo *et al.* (2021) reported comparable findings in Anambra state, Idowu *et al.* (2019) in Lagos state and Usang *et al.* (2020) in Cross River state. Low environmental sanitation and poor personal hygiene among the study population may be contributing factors that facilitate the higher prevalence of *A. lumbricoides*.

This study's high prevalence of STH infections among children residing in rural areas supports the findings of Idowu *et al.* (2022) and Elmonir *et al.* (2021) who reported comparable findings. This could be due to a number of factors, including the unsanitary conditions in rural areas, the limited availability of clean drinking water, the poor sewer drainage, and the high rate of animal interaction. The slightly high prevalence in male than females children reported in this work cannot inextricably link to the studies by Esiet and Ita, (2017), Usang *et al.* (2020) who made comparable findings. Similarly, the study found no recurring trends in the prevalence of STH infections with respect to age groups. This clearly shows that all studied children irrespective of gender and age group have equal exposure to these parasite agents. The significantly higher prevalence of STHs obtained with respect to place of residence, habits of playing with soil, non-washing of hands after defecation and walking barefoot supports the findings of Eyayu *et al.* (2021) and may be attributed to poor environmental sanitation that may inflict difficulty to maintain a good level of personal hygiene, resulting in favourable places for the development of STHs ova and hence could facilitate their transmission.

The high rate of anaemia found among infected children in this study supports the findings of Ahmed *et al.* (2012), Ihejirika *et al.* (2019) and Cho *et al.* (2021) who found low haemoglobin levels among individuals infected with the parasites. This could a result of the combine effects of the parasites isolated (Naing *et al.*, 2013). Numerous epidemiological studies have demonstrated an association between STH infections and nutritional status (Ajayi *et al.*, 2017). Children with mixed or moderate to heavy STH infections frequently experience more severe effects than single-specie or light infection (Mascarini-Serra, 2011). The nutritional status of STHs-infected children was shown to be lower than that of uninfected children in this study. This is consistent with studies by Tulu *et al.* (2016), Ajayi *et al.* (2017) Idowu *et al.* (2019) which found association between STH and malnutrition.

CONCLUSION

This study found STHs to be highly prevalent and an issue of public health among the children in the study area. Residence, habits of playing with soil, not washing hands after defecation and walking barefoot were the main risk factors for STHs prevalence among the children in the study area. STH infections is found be associated with malnutrition as significant number of infected children were thin (underweight).

RECOMMENDATION

Practicing good personal hygiene and maintaining proper sanitation is recommended to lower the prevalence of STH infections in the study area. The study also requires periodic follow-up assessments to gauge and monitor the threat of STH infection.

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