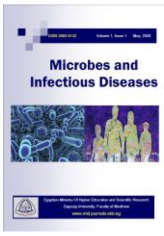
Microbes and Infectious Diseases 2024; Article-In-Press, **DOI:** 10.21608/mid.2023.250897.1679



Microbes and Infectious Diseases

Journal homepage: https://mid.journals.ekb.eg/

Original article

Prevalence and distribution of soil-transmitted helminthiasis among school-aged children in Kano, Northern Nigeria

Rabiu Adamu [1,2*]***, Nor Azwady Bin Abd Aziz*** [1]***, Muskhazli Mustafa*** [1]***, Shamarina Binti Shohaimi*** [1]

1- Department of Biology, Faculty of Science, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

ARTICLE INFO

Article history:
Received 27 November 2023
Received in revised form 25 December 2023
Accepted 29 December 2023

Keywords:
Soil-transmitted Helminth infections
prevalence
School-aged Children
Nigeria

ABSTRACT

Background: Soil-transmitted Helminth (STH) are species of nematodes spread by eggs present in human faeces which contaminate the soil and cause an infection called helminthiasis. There are three STH; Roundworm (*Ascaris lumbricoides*), Hookworm (*Ancylostoma duodenale* and *Necator americanus*), and Whipworm (*Trichuris trichiura*). The study investigates the prevalence and distribution of STH infections among primary school children (PSC) in Dawakin Kudu local government, Kano State, Nigeria. **Methods:** Fecal samples (n=560) were collected from randomly selected pupils between the ages of 5 – 16 years from seven primary schools (PS), 80 pupils were enrolled in the study from each school. The samples were examined for the presence of STH eggs or larvae using the formol-ether sedimentation technique and analysed using IBM SPSS statistics version 26. **Results:** Out of 560 PSC examined for infections, 357(63.8%) were males while 203 (36.2%) were females. An overall prevalence was 338 (60.4%) positive with STH parasite and only 52(9.8%) had mixed infections. The prevalence of STH was Hookworm 197 (35.2%), *Ascaris lumbricoides* 109 (19.5%), and *Trichuris trichiura* 32 (5.7%). Gender-specific rate for females 181 (32.3%) was higher than for males 157 (28.1%). The highest prevalence in both males 91 (16.3%) and females 106 (18.8%) was recorded in Hookworm infection and the least gender-specific infection was recorded in *Trichuris trichiura* infection with males 17 (3.0%) and females 15 (2.7%). However, there was no statistically significant difference in the prevalence of infection between gender (p=0.684) (p>0.05; 95% CL). The prevalence of parasites by age showed that the highest (18.9%) was recorded in children 8 – 10 years of age and the least prevalence (7.9%) was recorded between the 14 – 16 years age group. Across all four (4) age groups (5-7, 8-10, 11-13, 14-16 years), Hookworm had the highest prevalence (35.2%) and *Trichuris trichiura* infection was the least (5.7%) recorded prevalence. **Conclusion:** Programs such as public health enlightenment, regular de-worming exercises, supply of potable drinking water and personal hygiene should be intensified in the area particularly among children of school age.

Introduction

Soil-transmitted helminths (STHs) refer to the intestinal worms infecting humans that are transmitted through contaminated soil [1]. Soil-transmitted helminth infections are among the most common infections worldwide and affect the poorest

DOI: 10.21608/MID.2023.250897.1679

* *Corresponding author:* Rabiu Adamu
E-mail address: *gs60901@student.upm.edu.my*

and most deprived communities. They are transmitted by eggs present in human faeces which in turn contaminate soil in areas where sanitation is poor [2]. These STHs are considered neglected tropical diseases (NTDs) because they inflict tremendous disability and suffering yet can be controlled or eliminated [1]. The main species that infect human are the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*) and hookworms (*Necator americanus* and *Ancylostoma duodenale*) **(Fig. 1)**. These STH species are normally addressed as a group because they need similar diagnostic procedures and respond to the same medicines [2].

School age children (SAC) are one of the groups at high-risk for STH infections. The adverse effects of intestinal parasites among children are diverse and alarming [3]. Intestinal parasitic infections have detrimental effects on the survival, appetite, growth, physical fitness [4], school attendance and cognitive performance of school age children [5]. SAC bear the greatest burden from these infections, which are associated with anemia, malnutrition, growth and cognitive delays, inflammatory bowel disease and can negatively impact physical development and school performance [6]. Helminths infections can also negatively impact the progression of malaria and HIV/AIDS by increasing the severity of malaria-induced anemia and contributing to decreased hemoglobin levels which in turn increases the risk of mortality [5]. The incidence of human intestinal helminthic infestation is widely recognized to be quite general in tropical as well as in temperate countries. The intensity of infestation varies considerably in different population groups and form different localities [7]. Helminthic intestinal infection being a major public health problem in many developing countries like Africa, Saudi Arabia, Asia, and South America, whereas developed countries like the United States and Japan show very low incidence [4].

Methodology

Study area and population

The Gadar Tamburawa River is a river in Nigeria, 15 kilometres from Kano town along Zaria Road. The settlement is known as Tamburawa and located one and a half kilometres away from the river. It is a prominent town under Dawakin kudu Local Government, Kano state. The inhabitant of Tamburawa are Hausa, mostly Farmers, seasonal and irrigation farming is widely practiced. In the 2006 population Census, Tamburawa was marked with 11, 453 inhabitants. In September 2022 Nigeria population increased by 2.67% as projected by National Population Commission (NPC) in partnership with World Bank, United Nations International Children's Emergency Fund (UNICEF), World Health Organization (WHO), United Nations Statistical databases (UNData) and United Nations Fund for Population Activities (UNFPA). The projected population of Tamburawa was therefore 11,758 in 2022. The geographical location of Tamburawa is 11º 50' 4" N 8º 35' 53" E **(Figure 1)**, mean temperature ranges from 18 ºC to 20 ºC during the rainy season and 26 ºC to 30 ºC during the dry season. Rainfall is bimodal with the short rains between October to December and heavy rainfall between March and May. Mean annual rainfall ranges from 700mm to 1000mm. Dawakin kudu district has a population of 416,113 (427,223 in 2022) persons of which 48.6% are males. The district has 24 health facilities of which 1 is teaching hospital (Northwest University Teaching Hospital), 1 general hospitals, 3 comprehensive health centers, 15 primary health centers and 4 are basic health centers.

According to hospital records, STH remains the number one cause of hospital admissions and child morbidity and mortality in the district. Helminths transmission occurs throughout the year with peaks during the rainy seasons. Tamburawa district has many water bodies including small and large rivers, swamps and more than 10 ponds are all over the town particularly in areas along Zaria Road and Kumbotso Local Government boundaries.

Study design and sampling methods

The study was conducted between June, 2022 to January 2023, during which 560 children were examined with permission from the Primary Health Care Department (PHCD), Local Education Authority of Dawakin-kudu Local Government (DKLEA) and Kano State Ministry of Health (KSMoH). Fresh morning stool samples were collected in wide mouth plastic containers containing 10 ml of 10% formaldehyde. The containers were labeled, and immediately transported to Tetfund Research Laboratory (TRLab) at Sa'adatu Rimi University of Education, Kano for examinations. Study identification numbers were used instead of children's names and information collected was kept confidential.

Inclusion and exclusion criteria

Primary schools in Tamburawa village close to each other and close to the ponds or river and in each selected school, pupils in primary one and Early Child Center (ECC) classes were included in the study. However, children whose parents or legal guardians did not provide informed consent and children who received treatment or dewormed before the period of study were excluded.

Ethical considerations

Before commencement of the study, meetings were conducted with Education Secretary (ES), leaders and head teachers of all selected villages during which the objectives of the study were explained. The village leaders requested to convene village meetings during which sensitization of the communities will be carried out. During these meetings, the objectives of the study including the study procedures to be followed, samples to be taken, study benefits and potential risks and discomforts were explained. Informed consents for children to participate in the study were sought from parents and legal guardians after they have been clearly informed about the study. This investigation commenced by first reaching out to the heads of the seven schools explaining the objectives, possible outcomes, and benefits of the research. Informed consents were also obtained from the heads of the schools, and their class teachers. Children were also informed of their right to refuse to participate in the study and to withdraw at any time during the study without jeopardizing their right.

Ethical approvals

Ethical clearance was obtained from Primary Health Care Department (PHCD) Dawakin Kudu Local Government with reference number DKD/PHC/HIM/VII; 29/08/2021, Dawakin Kudu Local Government Education Authority (DKLGEA) State Universal Education Board, Kano with reference number DKD/LEA/EP/2021/09; 04/10/2021 and Research Ethics Committee, Kano State Ministry of Health (KSMoH), with reference number NHREC/17/03/2018; 14/10/2021 which was conveyed to the Headmasters (mistress) of the selected schools.

Ethical supervisory committee

The local government council constituted 10 members ethical supervisory committee (DKD/PHC/DSN/001; 06/07/2022) with experts from Disease, Surveillance and Notification Unit (DSNU), Essential Drugs Unit (EDU), Health Education Unit (HEU) and Health Information Unit (HIU) to monitor, supervise and report on the procedure of sample collection and adherence to all ethical rules and regulations. In addition, respondents with STH infections were treated with albendazole (400 mg single dose) for one day, except for those diagnosed with trichuriasis who received 400 mg of albendazole for 3 consecutive days. The drugs were provided to the committee by the local government.

Collection and examination of stool samples

Fecal samples were collected from 560 school-age children between 6 to15 years old. From each school, eighty (80) school children participated in the study. The samples were provided in a screw cap plastic containers and each plastic container with samples collected from each child was labelled with the child's identification number. The samples were immediately transported to be processed in the laboratory. The samples were examined for gastrointestinal parasites using formal-ether sedimentation technique. Each specimen was first examined macroscopically, and its consistency or nature was recorded in accordance with the description by [8,9]. The test procedures were carried out in accordance with standard protocols as described by Bhumbla in stool examination [10] and Kevin's procedure manual mount [11]. Formol–ether concentration technique is the most frequently used technique to concentrates a wide range of parasites with minimum damage to their morphology and it's important to increase the chance of detecting parasites [12].

Parasitological examination

The stool samples were properly labelled and were carried in a cold box filled with ice packs and transported to the laboratory for analysis. The samples that could not be analysed immediately were preserved using 10% formalin until they were examined [13]. Faeces (1g) were suspended in 10ml of 10% formaldehyde solution is mixed with a glass rod. The suspension was passed through a funnel covered with a gauze pad, to remove debris into a centrifuge tube. 3ml of ether was added and the suspension was thoroughly mixed. For safety reasons, diethyl ether solvent was replaced by ethyl-acetate, which has been shown not to affect the results [12]. The tubes were centrifuged for 3 minutes at 4000 rounds per-minute (rpm). Four layers were formed at the end of the centrifugation. The first layer was the ether with fats dissolved in it, the second was the debris, the third was the formaldehyde solution and the fourth was the sediment of eggs and/or larvae. The centrifuge tubes were decanted, leaving only the sediment. The sediment was examined by sampling a drop with a pipette and depositing it on a glass slide. The slide was covered with a slide cover slip and examined microscopically using X10 and X40 objectives of the microscope; each parasite was identified using District Laboratory Practice Manual for Tropical Countries (Second edition) by Cheesbrough as a guide [14]. The eggs per gram (epg) of faeces was calculated and used to estimate the infection intensity of the parasites based on the classification reported by WHO (2008) for major soil-transmitted helminths infections. Loose and watery stool specimens were not analysed by this method because of the technical difficulties that limit analysis of such specimens by this method [15,16].

Each specimen was examined by two independent qualified laboratory technologists. Specimens with discrepant results were reviewed with consultation among the two by a third reader. Quality control was performed on 10% of randomly selected samples and a repeated examination was performed by the same technologists without knowledge of their initial results [11-13].

Statistical analysis

A questionnaire was administered to each of the selected pupils to obtain information from them on age, sex, whether hands are washed after using toilet, whether fruits and vegetables are washed before eating, source of drinking water, water contact activities and whether eating together in a single bowl as well as method of waste disposal. The data obtained in the study were presented in tables, interpreted in percentages, and analysed with respect to age, sex, class, sanitation habits, types of toilet system used, source of drinking water, and contact with water bodies. Odds ratio was used to test for association between prevalence and the variables contained in the questionnaire. Chi-square was also be used to determine the association in prevalence among different schools by sex as well as age.

Results

An overall prevalence of Soil-Transmitted Helminths was 338 (60.4%) out of 560 samples collected and examined. The prevalence of occurrence of each parasite encountered in the study was Hookworm 197 (35.2%), *Ascaris lumbricoides* 109 (19.5%), and *Trichuris trichiura* 32 (5.7%) **(Table 1)**.

Prevalence and gender – specific of soil-transmitted helminth infection

The gender specific rate for females 181 (32.3) was generally higher than for males 157 (28.1). However, there was no statistically significant difference in the prevalence of infection between genders (***p***=0.684) **(Table 2)**. The highest prevalence in both males 91 (16.3%) and females 106 (18.8%) was recorded in Hookworm infection and the least gender specific infection was recorded in *Trichuris trichiura* infection with males 17 (3.0%) and females 15 (2.7%).

Age specific prevalence of soil transmitted helminths infection

The prevalence of parasites by age showed that the highest prevalence (18.9%) was recorded in children between 8 – 10 years of age and the least prevalence (7.9%) was recorded between 14 – 16 years age group. Across all the four age groups (5-7, 8-10, 11-13, 14-16 years), Hookworm had the highest prevalence, (35.2%) and *T. trichiura* infection was the least (5.7%) recorded prevalence among children examined in the sample schools **(Table 3)**.

Categorization of intensity of soil transmitted helminth infection

The rate of heavy infection was higher for Hookworm 14 (2.5%) and no heavy infection was detected due to *Ascaris species. Trichuris trichiura* had the lowest 17 (3.0%) recorded moderate infection. Total of (2.7%) infected children harboured high infection, while (40.6%) and (17.1%) infected children harboured low and moderate infections respectively. The mean parasite loads for Hookworm, *Ascaris lumbricoides* and *Trichuris trichiura* were 65.3, 34.7, and 12.7 eggs per gram (EPG), and the average low, moderate and heavy infections were 75.7, 32.0 and 5.0 respectively **(Table 4)**.

Effects of some social factors on the prevalence of soil transmitted helminthiases

Children with soil-transmitted helminths infections were more likely to be from parents/guardians who lived in a house with 4-5 households (OR = 2.938 95%, CI: 0.195 – 0.578). Farmers (OR = 4.950, 95% CI: 0.213 – 8.404) (***p***=0.004) had children who were approximately 5 times more likely to be infected with soil-transmitted helminths than children whose parents are civil servants or traders. Compared with children whose parents had attended tertiary education, school children whose parent had attended basic or secondary schools were more likely to be infected with soil-transmitted helminth (OR = 6.495, CI: 7.857 – 89.355; OR = 4.159, CI: 1.252 -13.812) (***p***=0.000). School-aged children with no prior knowledge of soil-transmitted helminth infections were 7 times more likely (OR = 7.508, 95% CI: 1.105 – 53.743) (***p***=0.000) to be infected with soil-transmitted helminths. The frequency of visits to hospital was significantly associated with soil-transmitted helminth infections. Children who sometime visit hospital were 4 times more likely at higher risk of infection with soil-transmitted helminths (OR= 4.428, 95% CI: 1.872 – 14.523) (*p*=0.000), whereas school children that had never visited hospital were 5 times more likely at higher risk of infection with soil-transmitted helminths (OR= 5.379, 95% CI: 7.857 – 89.355) (***p***=0.000) **(Table 5)**.

Table 1. Prevalence of soil-transmitted helminth infection among primary school children in Tamburawa, Dawakin kudu Local Government of Kano State

Parasites Identified	Number of Children Infected	Percentage
Hookworm	197	35.2
Ascaris lumbricoides	109	19.5
Trichuris trichiura	32	5.7
Total	338	60.4

Table 2. Gender – specific rates of soil-transmitted helminth infections among primary school children in Tamburawa, Dawakin-Kudu Local Government Area, Kano State

Parasites Identified	Male (N=357) No (%)	Female (N=203) No (%)	Number of Children Infected (N=560) No (%)	χ2	***p***- value
Hookworm	91 (16.3)	106 (18.9)	197 (35.2)	0.724	0.003
Ascaris lumbricoides	49 (8.8)	60 (10.7)	109 (19.5)	0.171	0.019
Trichuris trichiura	17 (3.0)	15 (2.7)	32 (5.7)	0.645	0.622
Total	157 (28.1)	181 (32.3)	338 (60.4)	0.273	0.684

Table 3: Age – Specific Rates of Soil-transmitted Helminth infections among Primary School Children in Tamburawa, Dawakin-Kudu Local Government of Kano State

Parasite Identified	Number of Children Infected				
	5-7 Years (n=90) No. (%)	8-10 Years (n=106) No. (%)	11-13 Years (n=98) No. (%)	14-16 Years (n=44) No. (%)	Total
Hookworm	43 (7.7)	62 (11.1)	67 (11.9)	25 (4.5)	197 (35.2)
Ascaris lumbricoides	39 (7.0)	33 (5.9)	21 (3.8)	16 (2.9)	109 (19.5)
Trichuris trichiura	8 (1.4)	11 (1.9)	10 (1.8)	3 (0.5)	32 (5.7)
Total	90 (16.1)	106 (18.9)	98 (17.5)	44 (7.9)	338 (60.4)

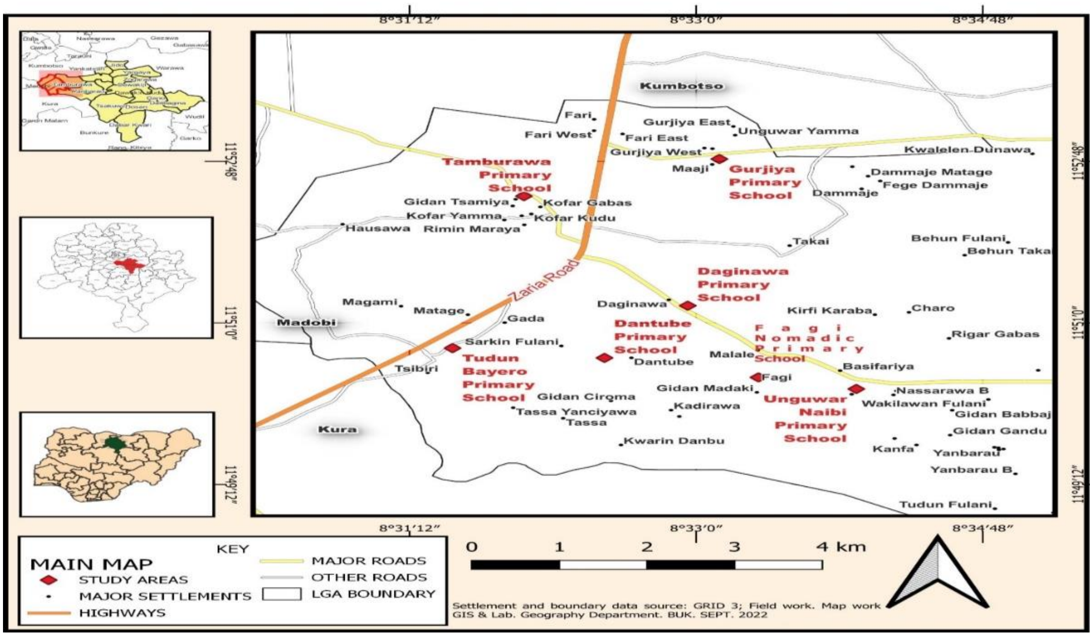
Table 4. Categorization of intensity of soil transmitted helminth infection among school children of Tamburawa in Dawakin Kudu Local Government of Kano State

	Infection Status			
Parasite Identified	Low (%)	Moderate (%)	Heavy (%)	Total (x̄ epg)
Hookworm	128 (22.9)	54 (9.6)	14 (2.5)	196 (65.3)
Ascaris lumbricoides	79 (14.1)	25 (4.5)	0 (0.0)	101 (34.7)
Trichuris trichiura	20 (3.6)	17 (3.0)	1 (0.2)	38 (12.7)
Total Average	227 (40.6) 75.7	96 (17.1) 32.0	15 (2.7) 5.0	338 (112.7)

Table 5: Prevalence of soil-transmitted helminthiases by social factors among school-age children in Tamburawa, Dawakin Kudu Local Government of Kano State

Variables	No. Examined (%) n= 560	Negative No. (%)	Positive No. (%)	OR (CI, 95%)	***p*** value
Number of Households					
1 - 3	352 (62.9)	207 (58.8)	145 (41.2)	1	
4 - 5	208 (37.1)	16 (7.7)	192 (92.3)	2.938 (0.195 – 0.576)	0.000
Occupation of Household					
Civil Servant	21 (14.6)	13 (61.9)	8 (38.1)	1	
Farming	478 (85.4)	177 (37.0)	301 (63.0)	4.950 (0.213 – 8.404)	0.004
Trading	61 (14.4)	32 (52.5)	29 (47.5)	1	
Level of Education of Households					
Basic	224 (40.0)	27 (12.1)	197 (87.9)	6.495 (7.857 – 89.355)	0.000
Secondary	312 (55.7)	176 (56.4)	136 (43.6)	4.159 (1.252 – 13.812)	0.000
Tertiary	24 (4.3)	19 (79.2)	5 (20.8)	1	
Knowledge of Soil-transmitted Helminths Infection					
Yes	52 (9.3)	40 (76.9)	12 (23.1)	1	
No	508 (90.7)	182 (35.8)	326 (64.2)	7.508 (1.105 – 53.743)	0.000
Visit to Hospital/Clinic/Health center					
Often	78 (13.9)	75 (96.2)	3 (3.8)	1	
Sometime	363 (64.8)	126 (34.7)	237 (65.3)	4.428 (1.872 – 14.523)	0.000
Never	119 (21.3)	21 (17.6)	98 (82.4)	5.379 (7.857 – 89.355)	0.000

Figure 1. Dawakin Kudu Local Government Area Showing the Study Areas**.** Source: Adopted and Modified from Dawakin Kudu Local Government Area Map 2022.



Discussion

In poor and developing countries of the world soil-transmitted helminths infections represent a major public health problem [17] and have constituted universal burden which does not depend on regional ecological conditions, but also on local standards of social and economic development of the people [18]. STH are group of nematode parasites with an essential phase of their asexual life cycle in the soil and there is a period persistence in the soil during which the infective stages are protected and preserved [19]. Infections by STH are most prevalent in areas where adequate water and good sanitations are lacking [20].

Recent estimates suggest that *Ascaris lumbricoides* infect over 1 billion people, 770 million with *Trichuris trichiura* and 800 million with hookworms (*Necator americanus* and *Ancylostoma duodenale*) [21].

School age children are one of the groups at high-risk for intestinal parasitic infections [20]. The findings of this study shows that an overall prevalence of soil-transmitted helminths was 338 (60.4%) out of 560 samples collected from PSC and examined. The prevalence of occurrence of each parasite encountered in the study was Hookworm 197 (35.2%), *Ascaris lumbricoides* 109 (19.5%), and *Trichuris trichiura* 32 (5.7%). Most of the school children go to school barefooted leading to the high prevalence of STH infections especially hookworm infections. Preliminary finding from the study area indicated ≥70% of the pupils have never taken anti-helminthic drugs in their life. This further accounted for the high prevalence of the STH egg/larvae in the stool samples and environment. Hookworm infection is influenced by habits such as not wearing footwear regularly [22]. Similar findings have been reported by [23] among PSC in Mozambique and among internally displaced persons (IDP) in Benin city, Nigeria [24]. In Calabar, Nigeria [25] reported the prevalence of hookworm infection to be significantly higher than infection with other soil-transmitted helminths in school children and this was attributed to the fact that most children did not wear shoes and walked over loamy soils and cultivated fields.

The prevalence of occurrence of *Ascaris lumbricoides* infection was 19.5%, (***p***=0.679). This was supported by studies done in Ogun, Enugu, Kano, and Ondo [26-28]. The predominance of *A. lumbricoides* could be related to the extreme resistance of the eggs to harsh environments than the other STHs [27]. Climatic variability, environmental factors, method, and type of control measure implementation might have contributed to the infection rate differences by gender across different regions [29]. For instance, the type of implementing control measures might affect the dominance of a certain worm within STHs due to worms having a unique susceptibility status for the applied anthelmintic drug as a preventive chemotherapy [30].

The high prevalence of *Ascaris lumbricoides* in the stool of these pupils could be due to unhygienic habit of not washing fruits and vegetables (OR = 2.678, 95% CI: 0.295 – 0.575) (***p***=0.001) before eating in school and due to their habit of picking and eating food like biscuits and sweets that had fallen on the ground as they play. This indicated that geophagia is a specific risk factor for infection with this orally acquired soil transmitted nematode.

In this study the prevalence of *Trichuris trichiura* (5.7%) (***p***=0.422) had the least occurrence of STH parasites encountered. However, male had 3.0% and female reported to have 2.7% prevalence. A low prevalence of *T. trichiura* infection has been reported in Ethiopia by [31] and Sub-Sahara African by [27]. Moreover, the low prevalence of *T. trichiura* could be attributed to the short-rainy session, during which the samples were collected and examined; as the environment becomes unfavourable for the formation of *T. trichiura* ova in the soil [32].

The prevalence of parasites by age showed that the highest prevalence (18.9%) was observed in PSC between 8 – 10 years of age and the least prevalence (7.9%) was recorded between 14 – 16 years age group. Across all the four (4) age groups (5-7, 8-10, 11-13, 14-16 years), Hookworm reported the highest prevalence (35.2%) and the least STH infection (5.7%) was *Trichuris trichiura* among children examined in the sample schools. In 2023, [20] supported this finding and reported a prevalence of 81.6%, 63.3% and 52.4% among children aged 12 -17 years, 16-11 years and 10-5 years respectively. Hookworm and *Ascaris lumbricoides* however were more prevalent among the older age group like the reports of [33] and however, the decrease of the prevalence with age particularly for *Ascaris* infection could be attributed to the fact that with increase in age the children are becoming more conscious of personal hygiene as well as development of resistance via increase of immunity [24]. While the increase of prevalence of infection with age for hookworm and *Trichuris* gives an indication of the exposure patterns of the children considering that they are becoming more active and adventurous with age [34].

The observation in the prevalence of helminths parasites with age is in conformity with the findings by [30] who reported that the worm burden of all three species of parasites decreased as children moved to higher classes. In a related study by [30] in Owo town, Ondo state, a total of 978 pupils were examined for soil transmitted helminths (STH) infections, consisting of 516 (52.76%) males and 462 (47.24%) females. The study indicated that 907 of the 978 children were positive for one or more helminths infection, therefore revealing a general prevalence of 92.74%. In all only three helminths were observed in the infected stool samples; these included *A. lumbricoides*, hookworm and *T. trichiura* deferent (***p***< 0.05) with age of subject. *A. lumbricoides* infection was the most prevalent parasite among the pupils, its prevalence though, decreased with age, and pupils within the age 5-7 years had the highest prevalence (90.26%) while those in age group 11-13 years recorded the least (68.97%) STH infections.

In this study the trend was unlike hookworm infection, as the prevalence increased with age, with the highest prevalence of 11.9% in age group 11-13 years while PSC in age group 14-16 years had the least (4.5%) prevalence of hookworm infection. Similarly, the prevalence of *Ascaris lumbricoides* followed trend of decreasing prevalence with age; 7.0% (5-7 years), 5.9% (8-10 years), 3.8% (11-13) and 2.9% (14-16 years). The higher prevalence of hookworm infection than that of *A. lumbricoides* infection and *T. trichiura* infection is consistent with the reports of [3] and [23], but disagrees with that of [34]. The high prevalence of *A. lumbricoides* infection may be attributed to high level of unhygienic practices among the pupils which enhanced transmission [35]. The presence of *Trichuris trichiura* infections in the study area was not unexpected since it is known that similar conditions which influence the endemicity of *Ascaris* species also influence its endemicity [36]. It is also known that *A. lumbricoides* infections are rarely found alone in human communities [37].

The gender – specific rate for females (32.3%) was generally higher than for males (28.1%) in this study and the highest prevalence in both males 91 (16.3%) and females 106 (18.8%) were reported in Hookworm infection and the least gender specific infection in *Trichuris trichiura* was reported with males 17 (3.0%) and females 15 (2.7%). However, there was no statistically significant difference in the prevalence of infection between by gender (***p***>0.05) among PSC in the study area. Supported by the previous study by [38] on prevalence and intensity of STH among primary school children in the Ngorongoro Conservation

Area (NCA), Tanzania, involving 340 primary school pupils of both sexes aged 6-14 years, it was conducted in 8 primary schools at different locations. Prevalence was 34.3% and 28.2% in males versus females, respectively. The distributions of the infections were not gender-dependent, and the between-sex prevalence was not statistically significant ($p > 0.05$). The findings from the study thus support the need for the establishment of a health program for the control of the helminths in the community.

The overall prevalence of infections among males and females (28.1%; 32.3%) was very close and showed no significant difference. This shows that school-age children are exposed to a similar risk of infection by these helminths. Similar results have been reported by [28] in Enugu, Nigeria, and [39] in Philippines. However, the prevalence of *T. trichiura* (3.0%) was higher in males than in females. A study in Ngorongoro conservation area, Tanzania, [38] reported helminths infection to be significantly higher in males than in females, but suggested that more studies should be done to ascertain whether helminths infection is gender dependent. In contrast, [34] in Ethiopia reported a high prevalence of *A. lumbricoides* and Hookworm among females compared to males and attributed this to different patterns of soil contact.

Conclusion

Improved sanitation by provision of modern toilet facilities, health education by enlightenment campaigns, school-based health programme and regular early deworming of pupils will go a long way in reducing infection. Prospective studies to access the impact of intestinal helminths in school children as regards their school performance, (intelligence and absenteeism) and growth is advocated. Education regarding geophagia prevention should be an integral component of the control programme. This would reduce the worm burden, reduce contamination of environment by these children and enable the pupils perform better in schools. It is therefore important that public health promotion be stepped up. Education is an important tool that can be used, and the primary school level is a good starting point.

Funding

This research received no external funding

Conflicts of Interest

The authors declare no conflict of interest.

References

1- **Vegvari C, Giardina F, Malizia V. De Vlas SJ, Coffeng LE, Anderson RM**. Impact of Key Assumptions about the Population Biology of Soil-Transmitted Helminths on the Sustainable Control of Morbidity. Clinical Infectious Diseases 2021; 72(Suppl 3), S188–S194. https://doi.org/10.1093/cid/ciab195.

2- **Johnson O, Fronterre C, Amoah B, Montresor A, Giorgi E, Midzi N, et al**. Model-Based Geostatistical Methods Enable Efficient Design and Analysis of Prevalence Surveys for Soil-Transmitted Helminth Infection and Other Neglected Tropical Diseases. Clinical Infectious Diseases 2021; 72(Suppl 3), S172–S179. https://doi.org /10.1093/cid/ciab192.

3- **Tian H, Luo J, Zhong B, Huang Y, Xie H, Liu L**. Challenges in the control of soil-transmitted helminthiasis in Sichuan, Western China. Acta Tropica 2019; 199. https:// doi.org/10.1016/j.actatropica.2019.105132.

4- **Dukpa T, Dorji N, Thinley S, Wangchuk Tshering K, Gyem K, Wangmo D, et al**. Soil-Transmitted Helminth infections reduction in Bhutan: A report of 29 years of deworming. PLoS ONE 2020; 15(1). https://doi.org/ 10.1371/journal.pone.0227273.

5- **Slepchenko SM, Bugmyrin SV, Kozlov AI, Vershubskaya GG, Shin DH**. Comparison of helminth infection among the native populations of the arctic and subarctic areas in western siberia throughout history: Parasitological research on contemporary and the archaeological resources. Korean Journal of Parasitology 2019; 57(6), 607–612. https://doi.org/10.3347/kjp.2019.57.6.607.

6- **Scavuzzo CM, Scavuzzo JM, Campero MN, Anegagrie M, Aramendia AA, Benito A, et al**. Feature importance: Opening a soil-transmitted helminth machine learning model via SHAP. Infectious Disease Modelling 2022; 7(1), 262–276. https://doi.org/ 10.1016 /j.idm.2022.01.004.

7- **Celestino AO, Vieira SCF, Lima PAS, Rodrigues LMCL, Lopes IRS, França CM, et al**. Prevalence of intestinal parasitic infections in Brazil: A systematic review. Revista Da Sociedade Brasileira de Medicina Tropical 2021; 54. https://doi.org/ 10.1590/ 0037-8682-0033-2021

8- **Santosh KA**. Microbiological Stool Examination: Overview. Journal of Clinical and Diagnostic Research 2012; (Suppl-1), vol-6(3): 503-509. https://www.researchgate.net/publication/236 303794.

9- **Demeke G, Fenta A, Dilnessa T**. Evaluation of wet mount and concentration techniques of stool examination for intestinal parasites identification at Debre Markos comprehensive specialized hospital, Ethiopia. Infection and Drug Resistance 2021; 14, 1357–1362. https://doi.org/10.2147/IDR.S307683.

10- **Bhumbla U**. Stool Examination. In Workbook for Practical Microbiology 2018; (pp. 142–142). Jaypee Brothers Medical Publishers (P) Ltd.https://doi.org/10.5005/jp/books/14206_1 7.

11- **Kevin CK**. Procedure Manual Mount. Sinai Hospital/Toronto Medical Laboratories Publishing, Ltd; 2000.

12- **Suwansaksri J, Nithiuthai S, Wiwanitkit V, Soogarun S, Palatho P**. The Formol-Ether Concentration Technique for Intestinal Parasites: Comparing 0.1 N Sodium Hydroxide With Normal Saline Preparations 2002;(33), Issue 3.

13- **Methanitikorn R, Sukontason K, Sukontason KL, Piangjai S**. Technical Report 2003; Evaluation of The Formalin-Tween Concentration Technique for Parasitic Detection. Comparative study [PubMed online]. Sep-Oct. 2003; 45(5): 289-91. Available from PubMed; Rev Inst Med Trop Sao Paulo. Accessed June 7, 2021.

14- **Cheesbrough M**. District Laboratory Practice in Tropical Countries Part 1; Second Edition. Cambridge University Press.; 2009.

15- **Khurana S, Sethi S**. Laboratory diagnosis of soil transmitted helminthiasis. Tropical Parasitology 2022; 7(2). https://doi.org/ 10.4103/tp.TP_29_17.

16- **Ngwese MM, Manouana GP, Moure PAN, Ramharter M, Esen M, Adégnika AA**. Diagnostic techniques of soil-transmitted helminths: Impact on control measures. In Tropical Medicine and Infectious Disease 2020;5(2).https://doi.org/10.3390/ tropicalmed 5020093.

17- **World Health Organization (WHO)**. Water Safety Plans-Training Package; Schematic life cycle of soil-transmitted helminths National Advocacy Seminar on Water Safety Plans. England, International Water Association (IWA) Press Ltd. 2023.

18- **Wong MTJ, Anuar NS, Noordin R, Tye GJ**. Soil-transmitted helminthic vaccines: Where are we now? Acta Tropica March 2023; vol-239: 78-84. Available from Elsevier, Accessed May 18, 2023.

19- **Sanyang AM, Joof E, Sey AP, Sambou S, Mohamed Z, Sanneh B**. Prevalence, and risk factors of strongyloidiasis among schoolchildren in Sabach Sanjal and Upper Badibou districts in the North Bank East Region of The Gambia. Parasite Epidemiology and Control. October 2021;15: 2405-6731. Available from: ScienceDirect, published by Elsevier Ltd. Accessed January 25, 2022.

20- **Uneke CJ**. Review; Soil transmitted helminth infections and schistosomiasis in school age children in sub-Saharan Africa: Efficacy of chemotherapeutic intervention since World Health Assembly Resolution 2001. In Tanzania Journal of Health Research 2010; 12(1). http://www.sci-ntds.org/

21- **Oluwafemi FS, Akharaiyi FC, Alo BE, Agunbiade BT**. Prevalence of soil transmitted helminths infection among primary school age children in Owo Town, Ondo State, Nigeria. International Journal of Veterinary Science 2019a; 8(4), 224–228.

22- **Pasaribu AP, Alam A, Sembiring K, Pasaribu S, Setiabudi D**. Prevalence, and risk factors of soil-transmitted helminthiasis among school children living in an agricultural area of North Sumatera, Indonesia. BMC Public Health 2019; 19(1). https://doi.org/10.1186/s12889-019-7397-6.

23- **Muadica AS, Balasegaram S, Beebeejaun K, Köster PC, Bailo B, Hernández-de-Mingo, M et al**. Risk associations for intestinal parasites in symptomatic and asymptomatic schoolchildren in central Mozambique. Clinical Microbiology and Infection 2021; 27(4), 624–629. https://doi.org/ 10.1016/ j.cmi.2020.05.031.

24- **Imalele EE, Braide EI, Emanghe UE, Effanga EO, Usang AU**. Soil-transmitted helminth infection among school-age children in Ogoja, Nigeria: implication for control. Parasitology Research 2023; 122(4), 1015–1026. https:// doi.org/10.1007/s00436-023-07809-3

25- **Clements ACA, Addis Alene K**. Global distribution of human hookworm species and differences in their morbidity effects: a systematic review. In The Lancet Microbe 2022;3(1):e72–e79.. https://doi.org/10.1016/S26665247(21)00181-6

26- **Edosomwan EU, Evbuomwan IO, Agbalalah C, Dahunsi SO, Abhulimhen-Iyoha BI**. Malaria coinfection with Neglected Tropical Diseases (NTDs) in children at Internally Displaced Persons (IDP) camp in Benin City, Nigeria. Heliyon 2020; 6(8). https://doi.org/10.1016/j.heliyon.2020.e04604

27- **Enogiomwan Imalele E, Offiong Effanga E, Ukam Usang A**. Environmental contamination by soil-transmitted helminths ova and subsequent infection in school-age children in Calabar, Nigeria. Scientific African 2023; 19. https://doi.org/10.1016/ j.sciaf. 2023.e01580.

28- **Aribodor DN, Bassey SA, Yoonuan T, Sam-Wobo SO, Aribodor OB, Ugwuanyi IK**. Analysis of Schistosomiasis and soil-transmitted helminths mixed infections among pupils in Enugu State, Nigeria: Implications for control. Infection, Disease and Health 2019; 24(2): 98–106. https://doi.org/10.1016/ j.idh.2018.12.003.

29- **Imam A, Farouk ZL, Hassan-Hanga F, Ihesiulor UG**. A comparative cross-sectional study of prevalence and intensity of soil-transmitted helminthic infection between healthy and severe acutely malnourished pre-school aged children in Kano, Northern Nigeria. BMC Infectious Diseases 2019b; 19(1). https://doi.org/10.1186/s12879-019-3755-3.

30- **Oluwafemi FS, Akharaiyi FC, Alo BE, Agunbiade BT**. Prevalence of soil transmitted helminths infection among primary school age children in Owo Town, Ondo State, Nigeria. International Journal of Veterinary Science 2019b; 8(4): 224–228.

31- **Taiwo A, Adedamola M**. An investigation on the epidemiology and risk factors associated with soil-transmitted helminth infections in Ijebu East Local Government Area, Ogun State, Nigeria. Scientific African 2021; 12: e00757.https://doi.org/10.1016/j.sciaf.2021.e00757.

32- **Gupta A, Acharya AS, Rasania SK, Ray TK, Jain SK**. Prevalence, and risk factors of soil-transmitted helminth infections in school age children (6-14 years) - A cross-sectional study in an urban resettlement colony of Delhi. Indian Journal of Public Health 2020; 64(4): 333–338. https://doi.org/10.4103/ ijph.IJPH_120_20

33- **World Health Organization (WHO)**. Digital Adaptation Kit for Antenatal Care; Operational requirements for implementing WHO recommendations in digital systems. Lancet Digit Health; 2021. Published Online February 17, 2021, https://doi.org/10.1016/S2589-7500(2)00038-8.

34- **Hailu GG, Ayele ET**. Assessment of the prevalence of intestinal parasitic infections and associated habit and culture-related risk factors among primary schoolchildren in Debre Berhan town, Northeast Ethiopia. BMC Public Health 2022; 21(1). https://doi.org/ 10.1186/s12889-020-10148-y.

35- **Gilmour B, Alene KA, Clements ACA**. The prevalence of soil transmitted helminth infections in minority indigenous populations of south-east Asia and the western pacific region: A systematic review and meta-analysis. PLoS Neglected Tropical Diseases 2021; 15(11). https://doi.org/10.1371/ journal.pntd.0009890

36- **Isaac C, Turay PN, Inegbenosun CU, Ezekiel SA, Adamu HO, Ohiolei JA**. Prevalence of soil-transmitted helminths in primary school playgrounds in Edo State, southern Nigeria. Helminthologia (Poland) 2019; 56(4): 282–295. https://doi.org/ 10.2478/helm-2019-0028.

37- **Elom MO, Usanga VU, Uhuo CA, Nwiboko UJ, Egwu SN**. Status of urogenital schistosomiasis and soil-transmitted helminthiasis co-infection among pupils in a rural setting of Ebonyi State, Nigeria. Nigerian Journal of Parasitology 2020; 41(1): 68–74. https://doi.org/10.4314/njpar.v41i1.11.

38- **Eltantawy M, Orsel K, Schroeder A, Morona D, Mazigo HD, Kutz S, et al**. Soil transmitted helminth infection in primary school children varies with ecozone in the Ngorongoro Conservation Area, Tanzania. Tropical Medicine and Health 2021; 49(1). https://doi.org/10.1186/s41182-021-00310-6.

39- **Mationg MLS, Tallo VL, Williams GM, Gordon CA, Clements ACA, McManus DP, et al**. The control of soil-transmitted helminthiases in the Philippines: the story continues. In Infectious Diseases of Poverty 2021;10(1). https://doi.org/10.1186/s40249-021-00870-z.