Afr. J. Med. Med. Sci. (2022) **52**(1) 51-61

Intensity of Soil-transmitted Helminths and associated environmental factors among School-age Children in a rural community in Southeastern Nigeria

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Abstract

Background: Soil-transmitted helminth (STH) infection remains a public health challenge. Monitoring intensity of STH and associated environmental factors are essential among school-age children (SAC) in developing countries. The study determined the infection intensity of STH and associated environmental factors among SAC in a rural community in southeastern Nigeria.

Methods: A cross-sectional study was conducted on 221 SAC in a rural community in southeastern Nigeria. The socio-demographic and Water, Sanitation and Hygiene practices were collected with a questionnaire and household sanitation facility and pet ownership with observational checklist. Stool and soil samples were collected and analyzed for STH intensity. Data was analyzed using descriptive and multiple regression analysis.

Results: A total of 221 SAC (9.3±2.5 years) provided information on socio-demographics and 149 (67.4%) gave stool samples. Hookworms (4.7%), *Strongyloides stercoralis* (2.7%) and *Enterobius vermicularis* (0.7%) were species identified. Intensity of STHs expressed as eggs or larvae per gram of stool (epg or lpg) showed light intensity for Hookworms (37.5±18.8) and heavy for *Strongyloides stercoralis* (25.2±0.1). Few (8.7%) were infected with at least one helminth and 66.5% SAC had recently dewormed (d"3 months). A filariform larva of *Strongyloides stercoralis* was found in a soil sample. About 61.5%, 75.0% and 60.0% participants indicated borehole as major source of drinking water, presence of household toilet facilities and pet ownership, respectively.

Conclusions: Soil-transmitted helminth intensity varied in school-age children in this study. Soil contamination with *Strongyloides stercoralis* larvae implies repeated infections despite periodic deworming. Environmental factors associated with infections among school-age children in this rural community should be addressed.

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Keywords: *School-Age Children, Helminth Intensity, Deworming, Soil-Transmitted Helminths*

Résumé

Contexte : L'infection par les helminthes transmis par le sol (HTS) reste un défi de santé publique. La surveillance de l'intensité des HTS et des facteurs environnementaux associés est essentielle chez les enfants d'âge scolaire (EAS) dans les pays en voie de développement. L'étude a déterminé l'intensité de l'infection par les HTS et les facteurs environnementaux associés parmi les EAS dans une communauté rurale du sud-est du Nigeria.

Méthodes : Une étude transversale a été menée sur 221 EAS dans une communauté rurale du sud-est du Nigeria. Les données sociodémographiques et pratiques d'Eau, d'Assainissement et d'Hygiène ont été recueillies à l'aide d'un questionnaire et l'installation d'assainissement du ménage et la possession d'un animal domestique avec une liste de contrôle d'observation. Des échantillons de selles et de sol ont été prélevés et analysés pour l'intensité des HTS . Les données ont été analysées à l'aide d'une analyse de régression descriptive et multiple.

Résultats : Un total de 221 EAS (9,3 ± 2,5 ans) ont fourni des informations sociodémographiques et 149 (67,4 %) ont fourni des échantillons de selles. Ankylostomes (4,7 %), *Strongyloidesstercoralis* (2,7 %) et *Enterobiusvermicularis* (0,7 %) ont été des espèces identifiées. L'intensité des HTS exprimée en œufs ou en larves par gramme de selles (epg ou lpg) a montré une intensité légère pour les ankylostomes (37,5 ± 18,8) et forte pour *Strongyloidesstercoralis* (25,2 ± 0,1). Peu (8,7%) étaient infectés par au moins un helminthe et 66,5% EAS avaient été récemment déparasités (d"3 mois). Une larve filari-forme de *Strongyloidesstercoralis* a été trouvée dans un échantillon de sol. Environ 61,5 %, 75,0 % et 60,0 % des participants ont indiqué le forage comme principale source d'eau potable, la présence de toilettes domestiques et la possession d'un animal domestique, respectivement.

Conclusions : L'intensité des helminthes transmis par le sol variait chez les enfants d'âge scolaire dans cette étude. Contamination du sol par *Strongyloidesstercoralis* implique des infections répétées malgré un déparasitage périodique. Les facteurs environnementaux associés aux infections chez les enfants d'âge scolaire dans cette communauté rurale devraient être adressée.

Mots-clés : *Enfants d'âge scolaire, Intensité des helminthes, Déparasitage, Helminthes transmis par le sol*

Introduction

Soil-Transmitted Helminth (STH) infections occur through transmission of parasitic worms to humans by faecally-contaminated soil with the highest prevalence in areas with inadequate sanitation [1]. Soil-transmitted helminth infections are still considered to be the most prevalent infections of humankind and the major species of medical importance include: *Ascaris lumbricoides* (roundworms), *Trichuris trichiura* (whipworms), *Ancylostoma duodenale* and *Necator americanus* (hookworms) and *Strongyloides stercoralis* (threadworm) [2]. Helminth and / or STH infections pose serious public health problems, especially among people in areas with inadequate hygiene and sanitation practices and where soil characteristics are conducive for helminth dwelling [3,4].

Consequently, high prevalence of STH has been associated with high STH eggs in soil samples [5]. Soil-Transmitted Helminths infections are common in tropical and subtropical regions of the developing world especially, in Sub-Saharan Africa (SSA), where poor domestic and environmental hygiene prevails [6]. Children, especially, SAC have the highest prevalence of helminth infections because they are most vulnerable to the factors that predispose them to the infections [7, 8].

Soil-transmitted helminths prevalence remains high in Nigeria and majority of those affected are young children between the ages of 5 and 14 years living in rural areas and urban slums [9], which creates the enabling environmental condition that result in a cycle of infection and re-infection. Therefore, environmental conditions, especially of the soil are important in the study of STH. Also, the aforementioned is important for noting because *A. lumbricoides, T. trichiura* and hookworms do not multiply in the human host but re-infection occurs only as a result of contact with infective stages in the environment [10]. Poor housing, inadequate sanitation and hygiene, walking barefoot, indiscriminate defecation, consumption of unwashed raw vegetables, being less than 15 years of age, playing in contaminated areas, adequate climate and soil environmental conditions are among the risk factors for infection in humans [11]. The aforementioned are typical characteristics of most rural communities and slums in Nigeria. Children growing up in such communities can be easily infected and reinfected repeatedly for the rest of their life [12]. Therefore, there is the need to provide information on STH intensity in rural communities in developing countries like Nigeria, where infections can be heightened owing to prevailing socio-economic and environmental factors. Additionally, information on soil environmental factors associated with STH infection is limited in many studies that have addressed prevalence of STH.

Umuogudu Oshia Ngbo community is one of the rural communities in Ngbo, Ebonyi State in southeastern Nigeria with low socio-economic status, poor sanitation and environmental conditions that favor survival of STH and can increase the development of their infections among school-age children. Important considerations for this study were: the study location classified within the endemic areas of the world for this most common neglected tropical disease and the need for adequate database for the control of the infection among school-age children. Therefore, this study was designed to determine infection intensity of STH and the associated environmental factors among SAC in a rural community in Southeastern Nigeria.

Materials and methods

Study area

This study was carried out in Umuogudu Oshia Ngbo community, Ohaukwu Local Government Area of Ebonyi State, Nigeria, located within the Ngbo area of Southeastern Nigeria. It lies between latitudes 6°30'N and 6°50'N and longitudes 7°80'E and 8°00'E with temperatures ranging from 20 to 38°C in the dry season and from 16 to 28°C in the rainy season. The average annual rainfall ranges from 1750 to 2250 mm [13]. It is a rural community with relatively low socioeconomic status and characterized with inadequate sanitary facilities often observed in most developing countries.

Study Design

A cross-sectional study was carried out among SAC in Umuogudu Oshia Community in Ohaukwu Local Government Area of Ebonyi State. Data was collected using a 50-item pretested semi-structured questionnaire completed by parents/caregivers on behalf of the pupils. The questionnaire comprised of questions on socio-demographic characteristics such as age, gender, religion, child's stage of education, as well as relevant demographics of parent/caregiver. Also included were questions on assessment of available water, sanitation and hygiene (WASH) practices and parents/caregivers level of knowledge about the risk factors of STH.

Also, an observational checklist was used to document the sanitary conditions of household of children with STH infections only, such as, hand washing facilities, type of house compound surrounding, rearing of pet animals and presence of trees within house compounds.

Study population

The study selected two public primary schools including: Ukpeshi Community Primary School and Okorogbata Community Primary School, in Umuogudu Oshia Community of Ohaukwu Local Government Area, Ebonyi State, Southeastern Nigeria. The study population comprised of SAC. A sample size of 221 SAC was calculated for the study using the formula for proportions [14] and prevalence rate of 15.5% obtained from a previous study [15].

Stool sampling and analysis

Stool samples for STHs analysis were collected from consented SAC in universal bottles using applicator sticks. The SAC were taught the appropriate procedure involved in the collection of their stool samples in the morning before coming to school. Identification numbers were created for each sample and questionnaire serial number of each SAC was written on the sample container. Not more than 20 samples were collected per day to avoid storage. Samples were kept in ice packs and transported immediately to the laboratory for analysis. Stool samples were processed using the Formol-Ether Concentration Technique for helminths extraction [17]. The preparations were examined under a microscope using the 10X and 40X objectives and the recovered helminths (eggs or larvae) were identified and counted by experienced laboratory personnel. Soil-transmitted helminths intensity infection was expressed as egg or larvae per gram of stool (epg or lpg), and compared with WHO classification for light intensity infection of 1 - 1999 (epg) for hookworms [17]. *Stongyloindes stercoralis* intensity was classified as low parasite load for 1 larva per gram of stool (lpg), moderate parasite load for 2 – 9 lpg and high parasite load for >10 lgp [18-20].

Soil sampling and analysis

School age children who had helminths in their stools were followed back to their various houses and soil samples were collected from their house surroundings. Separate soil samples 'at two depths (0 - 5 and 5 - 10 cm) were collected from the frontage and backyard from 3 - 5 points and were mixed thoroughly and a representative sample (500 g) was placed in a properly labeled bag for laboratory analysis. Soil samples were air-dried, sieved (< 2 mm mesh size) and analyzed for physicochemical parameters and STHs. Baermann's apparatus using the principle of thermotropism of larvae was used to determine STHs [21], and the filtrate was concentrated using Formol-Ether Concentration Technique. Soil pH (1:1 soil:water) was measured by glass electrode pH meter [22], while electrical conductivity was measured using a Jenway EC meter. Soil organic carbon was determined using Walkley-Black [23] method. The soil moisture content and texture were determined using gravimetric and hydrometer methods, respectively.

Statistical analysis

The socio-demographic characteristics of the SAC and parent/caregivers and Water, Sanitation and Hygiene practices were summarized using descriptive statistics (mean, frequencies, percentages and standard deviation). Multiple regression was utilized to assess whether environmental factors that describe children household surroundings [number of occupants per living apartment (NOpA), Drinking water sources (DWS), Solid waste management techniques (SWMT), Available sanitation services (ASS), Children hygiene practices (CHP) and rearing of pets within the household surroundings (PwHS)], were predictors of STH. Data analysis was carried out using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA) and significance was tested at $\alpha_{0.05.}$

Ethical Considerations

Ethical clearance for this study (UI/EC/17/0458) was obtained from the Joint University of Ibadan/ University College Hospital (UI/UCH) ethical committee review with a registration number NHREC/05/01/2008a. Additionally, approval to conduct the study was obtained from the Local Inspector of Education (LIE) in charge of the education district of the selected schools and heads of school, while informed consent was obtained from parent/caregivers of pupils through the Parent Teachers Association (PTA). After approval, selected schools' authorities nominated supervisors (two from each) to oversee all data collection stage particularly the stool sample collection. All information was treated with outmost confidentiality and participation in the study was totally voluntary.

Results

Socio-Demographic information

Socio-demographics characteristics of pupils who participated in the study are presented in Table 1.

Water, sanitation and hygiene practices

Water, sanitation and hygiene practice are presented in Table 2. The major sources of drinking water identified by the pupils were borehole (61.5%), rain water (61.1%) and well water (43.9%). Majority (72.3%) reported usual treatment of water before use. Approximately, half (51.1%) of the pupils reported waste disposal methods was dumping in nearby bushes, while 46.8% practiced burning. Findings from this study revealed inadequate sanitation facilities, since slightly above half (51.6%) practiced open defecation, others used open pit latrines (47.1%) and very few used water closet (11.3%) or baby potty (5.0%). Few pupils (9.0%) reported playing without footwear on regular basis while, majority (96.8%) usually wore footwear to the toilet. Hand washing after toilet use was reported by 56.1% of the SAC.

Table 1. Socio-demographics characteristics of the pupils and parents or caregiver

Characteristics	Frequency	Percentage	Mean±SD
Age in years			
5-9	113	51.1	
10-14	108	48.9	
Gender			
Male	110	49.8	
Female	111	50.2	
Mother's occupation			
Farmer	107	48.4	
Trader	66	29.9	
Civil servant	43	19.5	
Traditional birth attendant	3	1.4	
Artisan	2	0.9	
Father's occupation			
Farmer	70	31.7	
Civil servant	62	28.1	
Trader	55	24.9	
Artisan	32	14.5	
Mother's level of education			
No formal education	25	11.3	
Completed at least primary school	196	88.7	
Father's level of education			
No formal education	15	6.8	
Completed at least primary school	296	93.2	
Number of children in the family			5.9±1.8
Number of children within 5-14 years			2.5±1.2
Number of rooms in the apartment			3.8±1.6
Number of occupants per apartment			7.4±2.2
Reported deworming Episode (months)			
d"3	147	66.5	
>3-6	33	14.9	
>6	41	18.6	

SD – Standard Deviation

The mean age of the pupils was 9.3 ± 2.5 years, 51.1% were within 5-9 year of age while 50.2% were female. Less than half of the mothers and fathers engaged in farming (48.4% and 31.7%, respectively). Most of the children's mothers (83.6%) and fathers (93.6%) had at least primary education. The mean number of children per family and within the age of 5-14 years were 5.9±1.8 and 2.5±1.2, respectively. Number of room per apartment was 3.8±1.6 while number of person per apartment was 7.4±2.2. Overall, majority (80.4%) of the SAC reported they had been dewormed within the last 6 months while a greater proportion (66.5%) were dewormed within the last 3 months (Table 1).

Table 2. Respondents water, sanitation and hygiene (WASH) practices

Variables	Frequency	Percentage
Drinking water sources†		
Borehole water	136	61.5
Rain water	135	61.1
well water	97	43.9
Stream water	20	9.0
Treats water before use	159	72.3
Solid waste management technique		
Burning	103	46.8
Dumping in nearby bushes	113	51.1
Available sanitation facility†		
Open defecation	114	51.6
Open pit latrine	104	47.1
Closed pit latrine	18	8.1
Water closet	25	11.3
Baby potty	11	5.0
Mud for toilet floor	150	70.1
Mud for house floor	96	44.0
Children hygiene practices†		
Child plays without footwear always	20	9.0
Child plays without footwear sometimes	147	66.5
Child always goes to farm	19	8.6
Child goes to farm sometimes	183	82.8
Wears footwear to the toilet	214	96.8
Washes hands after toilet use	124	56.1
Washes hands before eating	219	99.1
Grows vegetables around the house	190	86.0
Ownership of pet/farm animals	144	65.2

†multiple response variable

Generally, regular hand washing before eating was practiced by almost all (99.1%) and 52.5% washed fruits before eating. Additionally, majority (86.0%) of the pupils reported growing vegetables around their home surroundings while 65.2% indicated ownership of pet/farm animals.

Table 3. Prevalence and intensity of helminth infections

Helminths	Status of infection		Mean intensity (epg / lpg stool)	Classification of infection intensity[c]		
	P (%)	N (%)		L	M	H
Single infection						
Hookworms[a]	7 (4.7)	142 (95.3)	37.5± 18.9	+	-	-
Stongyloides stercoralis[a]	4 (2.7)	145 (97.3)	25.3 ± 0.1	-	-	+
Enterobius vermicularis[b]	1 (0.7)	148 (99.3)	25.2 ± 0.1	+	-	-
Total						
Multiple infection						
Hookworms +						
Enterobius vermicularis	1 (0.7)	148 (99.3)				
Total	13 (8.7)	136 (91.3)				

epg = eggs per gram of stool; lpg = larvae per gram of stool; [a]soil-transmitted helminths; [b]helminth; [c]STH intensity classification (WHO, 2006 for eggs; Forer et al. 2017 for larvae); + = Yes; - = No; P = Positive; N=Negative; L=Light; M=Medium; H= Heavy

Soil-transmitted Helminths distribution

Table 3 shows the prevalence and intensity of helminths infection among the school pupils. Among the 149 stool samples analyzed, 13 (8.7%) were positive for at least one helminth infection. The mean intensity (epg or lpg) of Hookworm, *Strongyloides stercoralis* and *Enterobius vermicularis* were 37.5±18.9, 25.3±0.1 and 25.2 ± 0.1, respectively. The intensity of the helminth infection recorded was within the light intensity classification according to WHO [17] for hookworms but was heavy for *Strongyloides stercoralis* [20].

House surrounding characteristics of the infected children

Figure 1 shows the observation of the STH infected children's house surroundings. This revealed that 75.0% had toilet facilities, 100% had improvised hand washing facilities with soaps, although none (0.0%) of the households had sanitizer. Majority (60%) of the houses were located in the compounds made of mud/sand, 60.0% of the households had pet animals and 55.0% had trees within the compounds.

7.7±1.1 and 17.2±1.5, respectively for soil samples from the frontage of the households at the depth of 5 - 10cm. Soil samples from the backyard at 0 – 5 cm showed mean pH, organic carbon (%), electrical conductivity (µS/cm^{3}), moisture content (%) were 6.6±0.8, 1.1±0.4, 8.1±1.1 and 16.6±1.4, respectively. While pH, organic carbon (%), electrical conductivity (µS/cm^{3}) and moisture content (%) were: 6.5±0.7, 1.3±0.4, 8.1±0.9 and 16.8±1.3, respectively at 5 – 10 cm in soil samples from the backyard. The predominant soil texture of household frontage and backyard soil samples were sandy loam and loamy sand, respectively. Similarly, soil pH values in Ukpeshi Community Primary School were alkaline, while organic carbon was low and the moisture content was adequate for an ideal soil. Soil pH values in Community Primary School Okorogbata were mostly slightly acidic and moisture content was similar for both depths. The soil textures were either sandy or sandy loam. However, in Ukpeshi Community Primary School, Filariform larva (L3 Stage) of *Strongyloides stercoralis* was found in the backyard soil sample in 0 - 5 cm depth.

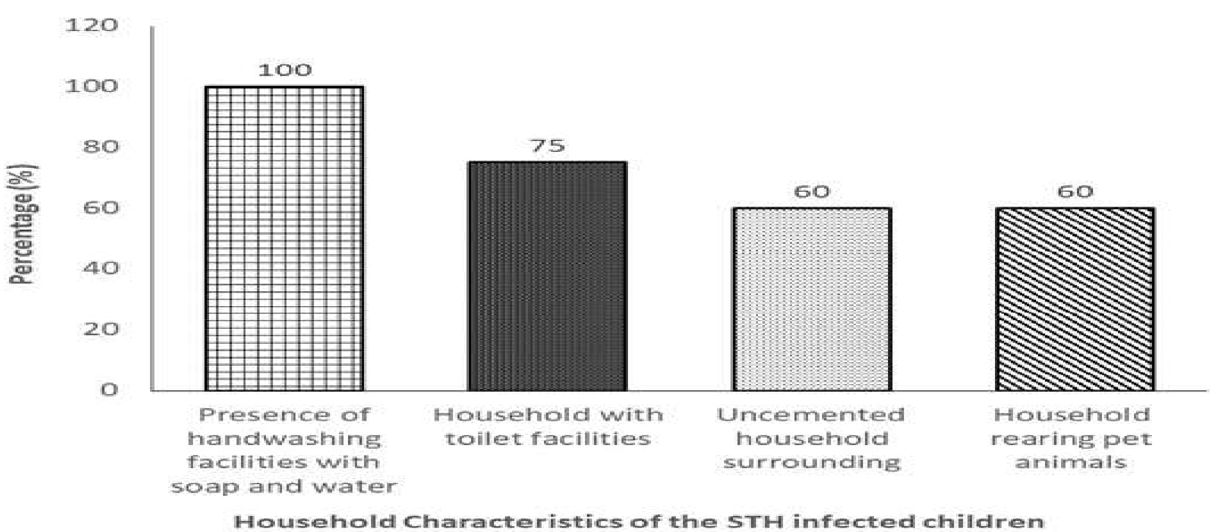

Fig. 1: Household sanitation and surroundings characteristics

Soil physico-chemical characteristics of schools and households' surroundings

Physicochemical characteristics of the SAC schools and household surroundings frontage and backyard soil samples are presented in Table 4. The mean pH, organic carbon (%), electrical conductivity (µS/cm^{3}), moisture content (%) were: 6.3±0.8, 1.04±0.5, 8.1±1.1 and 17.0±1.4, respectively for soil samples from the frontage of the households at the depth of 0 - 5cm. Mean pH, organic carbon (%), electrical conductivity (µS/cm^{3}), moisture content (%) were 6.3±0.8, 1.2±0.4,

Environmental factors and STH predictors among school age children

Predictors of STH among SAC were estimated using mutiple regression models as presented in Table 5. The predictors were number of occupants per living apartment (NOpA); Drinking water sources (DWS): Solid waste management techniques (SWMT): Available sanitation services (ASS); Children hygiene practices (CHP) and rearing of pets within the household surroundings (PwHS). Table 5 revealed that all the variables used as predictors in this study significantly ($p<0.05$) contributed to the prevalence of STH among the pupils.

Table 4. Soil physico-chemical parameters of households' and schools surroundings

Sample location and depth (cm)	pH	Organic Carbon (%)	Soil parameters Electrical conductivity (µS/cm³)	Moisture content (%)
Households' surroundings				
Frontage				
0-5	6.3±0.8	1.04±0.5	8.1±1.1	17.0±1.4
5-10	6.3±0.8	1.2±0.4	7.7±1.1	17.2±1.5
Backyard				
0-5	6.6±0.8	1.1±0.4	8.1±1.1	16.6±1.3
5-10	6.5±0.7	1.3±0.4	8.1±0.9	16.8±1.3
School surroundings				
Ukpeshi P. Schl.				
Frontage				
0-5	8.9±1.5	1.1±0.2	8.1±0.1	19.0±0.2
5-10	8.8±0.9	1.4±0.1	7.5±0.2	19.3±0.4
Backyard				
0-5	7.9±0.7	0.8±0.4	7.7±0.6	20.1±0.1
5-10	7.8±0.2	1.1±0.6	7.1±0.3	20.0±0.2
Okorogbata P. Schl.				
Frontage				
0-5	6.3±0.5	0.8±0.1	8.0±0.2	16.7±0.6
5-10	6.2±0.4	1.0±0.2	8.1±0.8	17.1±0.1
Backyard				
0-5	6.5±0.2	1.0±0.1	8.2±0.4	17.1±0.9
5-10	5.9±0.8	1.2±0.2	8.3±0.2	17.6±0.1

P – Primary; Schl – School

Table 5. Environmental factors and STH predictors among school age children

Variables	R square (Non Adjusted)	α (coefficient)	B	F/t (p Value)
Model	0.745			13.227 (<0.001)
NOpA		4.847	0.849	9.030 (0.001)
DWS		5.566	0.882	7.681 (<0.001)
SWMT		1.202	0.157	2.419 (0.003)
ASS		1.254	0.140	3.312 (0.009)
CHP		6.462	0.288	12.910 (<0.001)
PwHS		5.609	0.914	3.637 (0.007)
Constant		11.863		0.688 (0.492)

NOpA- number of occupants per living apartment; DWS- Drinking water sources; SWMT- Solid waste management techniques; ASS- Available sanitation services; CHP- Children hygiene practices; PwHS- rearing of pets within the household surroundings

Discussion

Soil-transmitted helminths infections are common in tropical and subtropical regions of the developing world especially in Sub-Saharan Africa, where poor domestic and environmental hygiene prevails [6]. Unsafe water supply is among the main sources of helminths transmission [10]. This study revealed rain water and borehole water as the major sources of drinking water, only a few of the household still depended on stream water as their drinking source.

In a study in Nigeria, primary school children who sourced drinking water from the stream were reported to have the highest prevalence of soil-transmitted helminthiasis [24]. Again, findings from this study showed that a high proportion of SAC reported wearing footwear to the toilet, which is similar to a study in Timor-leste, southeast Asia, where high proportion (63%) of the children wore footwear to the toilet [25]. The present study also found somewhat high percentage of SAC sometimes played around the household surroundings without wearing footwear. Children in the age group (<14 years) in this study have been suggested to be less cautious of their personal hygiene [24] and as such could walk barefoot. Younger children of pre-school age are far less cautious of their personal hygiene, thus very high proportion living in a peri-urban settlement in Nigeria have been reported to play without footwear [26].

More than half of the SAC reported practice of open defecation while some used open pit latrines. The relatively high proportion of open defecation practice reported in this study agrees with findings of previous studies in Nigeria [27, 28]. Open defecation in the current study confirms the ongoing challenge of inadequate sanitary facilities in Nigeria. Although a little less than half of the SAC reported latrine usage, this was about two times lower than another study in Indonesia that reported very high latrine usage for defecation by school children [8]. Open defecation will increase the potential for reinfection of the SAC despite periodic deworming by many children in the study area.

Two STH identified in this study were hookworm and *Strongyloides stercoralis* and another helminth (*Enterobius vermicularis)* not commonly found in soil was identified. However, hookworm had the highest intensity in this study. Interestingly, our study is similar to Pasaribu et al. [8] who also reported only one child was infected with *Enterobius vermicularis* in their study in Indonesia. The prevalence of STHs recorded in this study is low compared to Debalke *et al* [29] who reported 53.5% in government schools in Ethiopia. However, the prevalence is similar to the National average of 14.30% reported (~15 years ago) in Nigeria [30]. The low intensity observed for hookworms might be linked to the fact that large proportion (80.4%) of the SAC who participated in this study had been dewormed in the last six months, while 66.4% were dewormed within the last three months prior to this study. This does not mean that the low intensity of infections is acceptable, greater effort is needed to totally eradicate all helminth infections. The goal of any preventive chemotherapy intervention of STH is to achieve reduction to zero intensity [31]. The occurrence of hookworms as the most prevalent is in agreement with the report of another study among primary school children in Imo State, Nigeria [24].

Other studies in the Southeast of Nigeria also reported hookworms as the most prevalent [32-34]. However, *Ascaris lumbricoides and Trichuris trichiura* infections were not observed in this study as in some previous studies in the country [24, 35]. *Ascaris and Trichuris* have been reported to have higher prevalence in urban environments in some instances. In contrast, hookworm infections are typically high in areas where rural poverty predominates [36]. This study revealed STH infections from hookworms and *Enterobius vermicularis* fell into the light intensity classification [17] and is comparable to findings of Pasaribu *et al*. [8] that also reported light intensity in their study. However, low number of egg per gram (epg) should not be underrated as it has been suggested to impact children's health negatively [8]. Additionally, dual STH infection (hookworms+ *Enterobius vermicularis*) was found only in one child in this study. Other studies also reported dual and triple STH infections in SAC [8]. It is important to note that the intensity infections of *Strongyloides stercoralis* in this study was high based on previous classification [20]. This may explain the presence of a larvae form of this STH found in one of the soil samples in this study.

In the life cycle of these helminths, the soil receives (by faecal contamination) stages which are not infective but provides optimal conditions for development to the infective stage [37]. Additionally, the soil provides protection for the infective stage for a period, during which it may be brought into contact with a susceptible individual by the mouth or the skin [37]. Contaminated soils are important sources of STH infections, thus information on soil properties conducive for the development and survival of STH which are not usually addressed in STH studies are important. In this study, most of the soil sampled around households had pH ranging from slightly acidic to moderately alkaline, a condition that supports soil helminth multiplication. Generally, soil acidity information is still rarely collected, yet this is an important potential determinant for survivability of helminths [25].

Also, the organic carbon content for all soil samples in this study was low [38]. However, it should be noted that high level of organic carbon has been reported to encourage rise in the prevalence of STHs [39]. Further, this study also revealed adequate moisture in the soil sampled around the households. Soil moisture is important for STH survival and supports larvae movement, however, increase in moisture has been reported to reduce the availability of *Ascaris* eggs as they may move downward and become buried deep in the soil [40]. The soil texture was mostly sandy loam around the households. In addition, a Filariform larva (L3 Stage) of *Strongyloides stercoralis* was found in the backyard soil sample (0-5 cm depth) from one of the selected primary schools. This is important to note as *Strongyloides stercoralis* remains one of the highly neglected intestinal nematode, transmitted through infective larvae living in fecally-contaminated soils, particularly in tropical climates [41].

Also, Umar and Bassey [42] reported that the survival of free living form of *Strongyloides stercoralis* is favored by damp, sandy or friable soil with decaying vegetation and contaminated with human excreta. Further, they added that optimal conditions such as warmth, oxygen, light and moisture are required for the survival of its free living larvae in the soil.

Additionally, other environmental factors that predicted STH prevalence among the study participants included; number of occupants per living apartment, drinking water sources, solid waste management techniques, available sanitation facility, children hygiene practices, and rearing of pets within the household surroundings. Pasaribu et al. [8] also found children's personal hygiene was associated with the prevalence of STH in their study.

In conclusion, the study identified two STHs (hookworms, *Strongyloides stercoralis*) and another helminth (*Enterobius vermicularis*) rarely found in soil among the School-age children in the study area. Generally, helminths intensities (hookworms and *Enterobius vermicularis*) were within the light intensity threshold and hookworm had the highest prevalence. Low STHs intensity was recorded because majority of the participants had been dewormed within three months prior to the study. However, it is important to note that the intensity infection of *Strongyloides stercoralis* was high in this study. The sources of drinking water in the study area were mainly rain, borehole and well water. Poor waste management and open defecation characterized the area. Only few had water closet, never played without footwear, and majority of the parents were farmers. The soil physico-chemical parameters support multiplication of STHs. The predictors of STH among the school-age children in this study were number of occupants per living apartment, drinking water sources, solid waste management techniques, available sanitation facility, children hygiene practices, and rearing of pets within the household surroundings. These household surrounding features contributed more to the prevalence of STH and improvement on these features could reduce the occurrence of STH. Therefore, preventive chemotherapy should be combined with provision of safe water and sanitation facilities to reduce infection while preventing reinfection among school-age children.

Acknowledgements

The authors acknowledge the immense contribution of all the participants in the study.

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Received = 23/07/2021
Acceoted = 06/01/2022