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Comparative assessment of intestinal helminths prevalence in Water, Sanitation and Hygiene (WASH) intervention and non-intervention communities in Abeokuta, Nigeria

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ABSTRACT

Objective: This study compared the prevalence of intestinal helminths in Water, Sanitation and Hygiene (WASH) intervention and non-intervention communities in Abeokuta, Nigeria.

Methods: Stool samples were collected from 225 respondents in a study carried out between July and November, 2014. Stool samples were examined for presence of helminths using Formol-Ether concentration method. Data collected from stool samples were analyzed using SPSS for Windows (version 16).

Results: Results showed that, at the intervention community, 88 out of 113 respondents were infected with at least one helminth infection while at non-intervention community, 80 out of 112 respondents were infected. This result revealed overall helminth prevalence of 78% at Mawuko and 71% at Isolu. In both intervention (Mawuko) and non-intervention (Isolu) communities, hookworm was the most prevalent helminth observed (21% and 18%, respectively) followed by *Ascaris lumbricoides* (13% and 13%, respectively), *Taenia* sp. (4% and 3%, respectively) and *Trichostrongylus* sp. (1% and 3%, respectively). Cases of single infections of *Trichuris trichiura*, *Strongyloides stercoralis* and *Hymenolepsis nana* were observed only at the non-intervention community. However, *S. stercoralis* occurred in the multiple infections observed at the intervention community. Significantly more ($p < 0.05$) cases of infections were observed in male (46%) at the intervention community than female (31%) while in non-intervention community females (39%) were significantly ($p < 0.05$) more infected than their male counterparts (32%).

Conclusions: This study concludes that the Community Led-Total Sanitation intervention programme, which was executed in Mawuko was not effective as expected.

1. Introduction

Helminths are complex eukaryotic organisms with large genomes, endowing some species with the ability to live for decades in human host. Nematodes (Roundworms), Cestodes (tapeworms) and trematodes (flat worms) are among the most common helminths that inhabit the human gut [1]. These are four common species of intestinal helminthic parasites, known as geohelminths and soil transmitted helminths (STHs). They are *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Ancylostoma duodenale* and *Necator americanus* (hookworms). Helminth infections are most prevalent in tropical and subtropical regions of the developing countries where adequate water and sanitation facilities are lacking [2]. They are a major health problem in many developing countries infecting an estimated one-sixth of the global population [3]. Infection rates are highest in children living in Sub-Saharan Africa (SSA), followed by Asia, Latin America and the Caribbean largely due to high rate of poverty [4]. Infants growing up in an endemic community where sanitation and waste disposal facilities are inadequate are usually infected soon after weaning. The presence or absence of sanitary facilities at home had been established as a strong determinant

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of the prevalence of gastro-intestinal parasites [5–7]. Feachem *et al.* [5] reported 20% reduction in the prevalence and intensity of intestinal parasitic infection through provision of water, sanitation and improvement of personal hygiene in communities. Interventions to solve helminthiasis problems in humans rely mostly on chemotherapy aimed at destroying the parasites in the short-term and improved hygiene and sanitation in the long-term [8]. Factors enhancing exposure to *A. lumbricoides* eggs identified by previous studies include the lack of latrine [9], defecation practices [10], geophagia, the level of sanitation in households [11] and lower socio-economic status [12]. Simply walking barefoot in areas endemic to hookworm leaves people exposed to the disease. As a result, people can be continually re-infected as they work, play, bathe or eat. Children have a high risk of contracting these diseases, because they often play barefoot outside and put their hands in their mouths without washing them [13]. In Nigeria, infections caused by intestinal parasites are a public health problem while poor socio-economic environment is a major factor facilitating the prevalence of the disease [14]. The prevalence rate of intestinal parasites varies considerably in different parts of Nigeria. Studies had shown that *A. lumbricoides* is the most prevalent, followed by hookworms, *T. trichiura* and *Strongloides stercoralis* [15,16]. However, in some parts of Nigeria, hookworm has been reported as the most prevalent [17,18]. Furthermore, *T. trichiura* had been reported as the most prevalent in parts of Lagos and Oyo [15,19]. The objective of this study is to compare the prevalence of intestinal helminths in Water, Sanitation and Hygiene (WASH) intervention and non-intervention communities in Abeokuta, Nigeria.

2. Materials and methods

2.1. Study area

The study was conducted in Mawuko and Isolu communities located in Abeokuta suburb in Odeda Local Government Area (LGA) of Ogun State. Mawuko is a developing community with about population of 1200 people (personal communication). The residents constitute the local indigenes (Egbas, Igedes, Igbos) and students of Federal University of Agriculture, Abeokuta (FUNAAB). Most of the indigenes live in small houses with rusted aluminum roofing sheets. A public primary school and market buildings are located in the center of the community. Their occupations are predominantly farming, hunting and trading. Isolu is a fast developing community with population of 1500 people (personal communication). It is situated along Alabata road opposite the Federal University of Agriculture, Abeokuta International School (FUNIS). The inhabitants are local indigenes, FUNAAB staff members and students. Local indigenes are predominantly Egbas and Igedes. Their occupations include farming, trading, bricklaying, carpentry and hunting. Figure 1 shows the sampling sites (intervention and non-intervention) in Odeda LGA.

2.2. Sample collections

The sample bottles were given to the respondents according to the calculation of Yamane [20] for determination of sample size. At Mawuko, only 113 respondents (63 males and 50 females) returned their bottles with stool samples while 112 samples (54 males and 58 females) were returned at Isolu.

Helminth prevalence (p) was calculated as:

$$p = \frac{\text{Number of infected stools}}{\text{Total number of respondents}}$$

2.3. Examination of faecal sample

Faecal stool samples were collected with universal bottles that were distributed to the residents. Upon distribution, each bottle was marked with identification number, which was later correlated against the respondents' demographic information. The collected samples were taken to the parasitology Laboratory of the Department of Pure and Applied Zoology, Federal University of Agriculture, Abeokuta for macroscopy and microscopy examinations using Ether concentration method.

2.4. Laboratory analysis

Formal-Ether concentration method was employed in the detection and estimation of helminth ova in the fecal samples as described in Oyeyipo *et al.* [21]. An approximately 1.0 g of stool sample was suspended in 10 mL of 10% formaldehyde solution and mixed with applicator stick. The suspension was passed through a funnel covered with a gauge to remove debris into a bigger tube. Approximately 3 mL ether solution was measured and added into the tube and capped. The suspension was shaken thoroughly to get a mixture that was transferred into a centrifuge tube and centrifuged for 3 min at 2000 rpm. An applicator stick was used to remove the characteristic layer in the centrifuge tube. The tube was inverted quickly and carefully to dispose the content leaving the sediments. The sediments were then examined by putting a drop on a clean grease free glass slide covered with a cover slip and examined for the presence of helminth parasites with a microscope set at 10× and 40× objectives.

2.5. Demographic characteristics, sanitation and hygiene

Questionnaires were also administered to the consented residents to obtain their demographic information and to evaluate their knowledge about intestinal helminths, to obtain their knowledge, attitude and practices towards sanitation and hygiene and to record information about sanitary facilities.

2.6. Ethical approval

Ethical clearance was obtained from the Ogun State Rural Water Supply and Sanitation Agency (RUWASAN) and the leaders of the two communities (Mawuko and Isolu). The residents who gave their consents were enrolled for the study.

2.7. Data analysis

Data from questionnaire and laboratory analyses were collated and analyzed for simple descriptive statistics, analysis of variance (F-test) and student t-test using SPSS for Windows (version 16) statistical package.

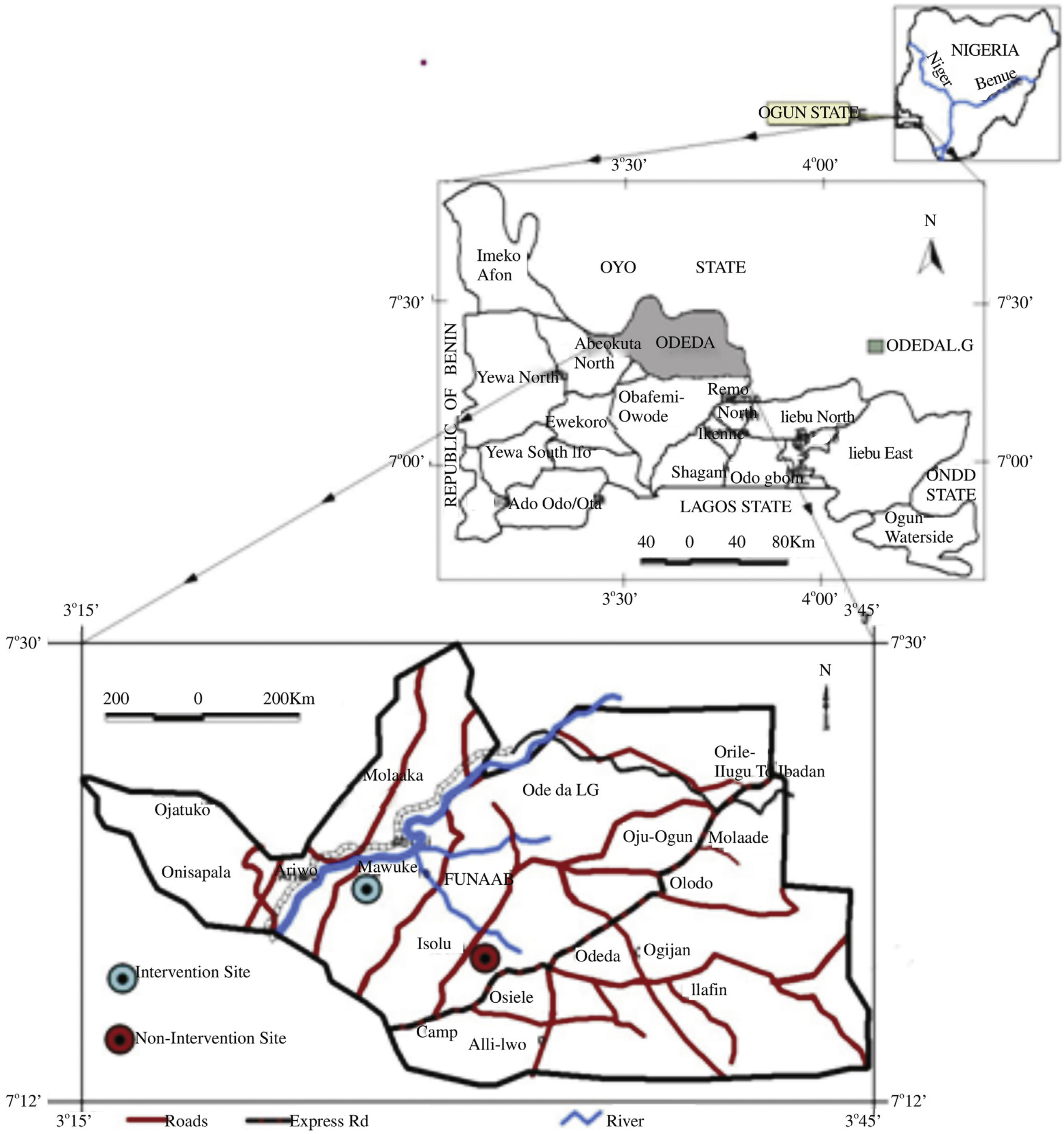

Figure 1. The map of intervention and non-intervention sampling sites in Abeokuta suburb of Odeda LGA (inset are Ogun State and Nigeria maps).

3. Results

3.1. Prevalence of helminths in intervention and non-intervention communities

Table 1 shows the demographic data of the respondents from the intervention (Mawuko) and non-intervention (Isolu) communities both in the Abeokuta suburb (Odeda Local Government Area of Ogun State), Nigeria. Intervention community represented the community that had been sensitized of the Water, Sanitation and Hygiene (WASH) programme by the United Nation Children Education Fund (UNICEF) on the need for every house to have a toilet facility [22]. The aim of the programme is to reduce helminth infections through Water, Sanitation and Hygiene.

During this study, a total number of two hundred and twenty five (225) respondents were examined at the two study areas (113 in Mawuko and 112 in Isolu). Table 1 presents the demographic characteristic of the respondents. Demographic data showed the domination of male at Mawuko (56%) and female at Isolu (52%). The majority of the respondents were students (51% at Mawuko and 49% at Isolu). The study also revealed that most respondents use bush as a mean of defecation, especially at the non-intervention site (63%).

The prevalence of intestinal helminths in the two study areas is presented in Table 2. In intervention (Mawuko) and non-

Table 1

Demographic information of the respondents in the two study areas.

	Mawuko		Isolu	
	Frequency	%	Frequency	%
Sex				
Male	63	56	54	48
Female	50	44	58	52
Total	113	100	112	100
Age				
1–10 yrs	41	36	38	34
11–20 yrs	21	18	22	20
21–30 yrs	15	13	19	17
31–40 yrs	17	15	16	14
41–50 yrs	12	11	6	5
51–60 yrs	3	3	3	3
61–70 yrs	4	4	4	4
71–80 yrs			3	3
81–90 yrs			1	1
Total	113	100	112	100
Occupation				
Student	58	51	55	49
Trading	22	19	21	19
Artisan	16	14	11	10
Civil service	6	5	3	3
Farming	2	2	13	12
Driving	2	2	3	3
Clergy	2	2	–	–
Unemployed	5	4	6	5
Total	113	100	112	100
Toilet facility				
Water closet	32	28	2	2
Pit	38	34	39	35
Bush defecation	53	47	71	63
Total	113	100	112	100

intervention (Isolu) communities, hookworm was the most prevalent helminth (21 and 18% respectively) followed by *A. lumbricoides* (13% each). Hookworm infection was significantly higher ($p < 0.05$) at the intervention community than those of the non-intervention community while no significance was established for *A. lumbricoides* infections. The incidence of *Taenia* sp. was also significantly higher ($p < 0.05$) at the intervention community while *Trichostrongylus* sp. was higher at non-intervention community. Cases of singular infections of *T. trichiura*, *Strongyloides stercoralis* and *Hymenoplesis nana* were absent at the intervention communities. However, *S. stercoralis* occurred in the multiple infections (polyparasitism) cases recorded in the intervention community. Out of 113 stool samples analyzed at the intervention community, 88 were tested positive for at least one helminth given an overall prevalence of 78%. At the non-intervention community; 80 of the total 112 stool samples tested were positive for helminths showing a prevalence of 71%.

The multiple infection cases observed during this study are shown in Table 3. The highest prevalence of helminth multiple infections was established for hookworm + *Ascaris*, which represented 20% at intervention community (Mawuko) and 14% at non-intervention community (Isolu). Among the multiple infection cases, *T. trichiura* and *H. nana* were observed only in non-intervention community. At the intervention community, *E. vermicularis* infection was identified. The total prevalence of multiple infections was 38% at the intervention and 31% at non-intervention communities. The prevalence value was significantly higher ($p < 0.05$) in Mawuko than Isolu.

3.2. Relationship between helminths prevalence and respondents' demographic characteristics

3.2.1. Gender prevalence of helminthiasis

The overall gender prevalence of helminthiasis between the intervention and non-intervention communities are presented in Table 2. In the intervention community, hookworm (15%), *Taenia* sp. (3%) and multiple infections (21%) were predominantly higher ($p < 0.05$) in males than females. *Trichostrongylus* sp. infection was diagnosed only in male subjects. In non-intervention community, female gender had the higher prevalence of *A. lumbricoides* (9%) and *Trichostrongylus* sp. (2%). There were infections of *T. trichiura* and *H. nana* in female gender in non-intervention community only. In terms of overall prevalence of helminths, higher cases of infections were observed in males (46%) at the intervention community than female gender (32%). This indicates that 59% of helminth infected people in the intervention community (Mawuko) were males. A contrary observation was documented in non-intervention community (Isolu) where the overall prevalence was significantly higher ($p < 0.05$) in female (39%) than male subjects (32%). This showed that 55% of infected people in non-intervention community were females.

Table 2

Prevalence of helminth infections by sex in intervention and non-intervention communities.

	Intervention (Mawuko)					Non-intervention (Isolu)					*p*-Value
	Total no tested	Male		Female		Total no tested	Male		Female		
		No of positive cases	% Prevalence	No of positive cases	% Prevalence		No of positive cases	% Prevalence	No of positive cases	% Prevalence	
Hookworm	113	17	15	7	6	112	11	10	9	8	0.000
Ascaris lumbricoides	113	7	6	8	7	112	5	4	10	9	0.002
Taenia sp.	113	3	3	2	2	112	2	2	1	1	0.119
Trichostrongylus sp.	113	1	1	0	0	112	1	1	2	2	0.009
Trichuris trichiura	113	0	0	0	0	112	0	0	1	1	
Strongyloides stercoralis	113	0	0	0	0	112	1	1	1	1	
Hymenoplesis nana	113	0	0	0	0	112	0	0	1	1	
Multiple infections	113	24	21	19	17	112	16	14	19	17	0.000
Overall prevalence	113	52	46	36	32	112	36	32	44	39	

Table 3

Prevalence of helminth multiple infections in the study area.

Multiple infections	Total no tested	No of positive cases	% Prevalence	Total no tested	No of positive cases	% Prevalence
	Mawuko			Isolu		
Hookworm + *Ascaris*	113	23	20	112	16	14
Hookworm + *Trichostrongylus*	113	5	4	112	7	6
Hookworm + *Taenia* sp.	113	3	3	112	1	1
Hookworm + *E. vermicularis*	113	2	2	112	0	0
Hookworm + *Strongyloides*	113	1	1	112	2	2
Hookworm + *Trichuris*	113	0	0	112	1	1
Ascaris + *Strongyloides*	113	1	1	112	0	0
Ascaris + *Taenia* sp.	113	3	3	112	2	2
Ascaris + *E. vermicularis*	113	1	1	112	0	0
Ascaris + *Trichostrongylus*	113	0	0	112	2	2
Taenia sp. + *Trichostrongylus*	113	1	1	112	0	0
Taenia sp. + *Strongyloides*	113	0	0	112	1	1
Ascaris + Hookworm + *Trichostrongylus*	113	1	1	112	2	2
Ascaris + Hookworm + *Taenia* sp.	113	1	1	112	0	0
Ascaris + Hookworm + *E. vermicularis*	113	1	1	112	0	0
Hookworm + *Taenia* + *Strongyloides*	113	0	0	112	1	1
Total	113	43	38	112	35	31

3.2.2. Prevalence of helminthiasis by age

Figure 2 shows the helminth data and age relationship at the intervention and non-intervention communities. No age significance ($p > 0.05$) was found between the intervention and non-intervention communities except for age group 41–50 years where higher prevalence was observed in the intervention community. In the intervention community, the highest prevalence was established for respondents in the age bracket 1–10 years, followed by 11–20 years and 31–40 years in that order. The *t*-test statistics showed significance ($p < 0.05$) between the incidence of helminth and age in intervention community. The highest prevalence of hookworm was found in the age group of 11–20 years. At least one helminth infection was found in the age groups 61–70, 71–80 and 81–90 years.

3.2.3. Prevalence of helminthiasis by occupation of the respondents

The total helminthiasis prevalence by occupation at the intervention and non-intervention communities was presented in Figure 3. At the intervention site, helminth infections were significantly ($p < 0.05$) found highest in students, followed by traders and artisans. Cases of infections were observed for civil servants, farmers, drivers, clergy and unemployed respondents. Similar occupational exposure trend to helminth infections was also observed in non-intervention site with students having the highest prevalence followed by traders and farmers.

Table 4 shows the results of multivariate statistics of principal component analysis (PCA) conducted on the helminth infections at both the intervention and non-intervention community. The essence of this is to identify the likely sources of the helminths. Two possible sources were identified by the PCA where the overall variance was 92.6%. Factor 1 has high loadings for *Trichostrongylus* sp., *T. trichiura*, *S. stercoralis* and *H. nana*. This factor has anti-correlation relationship with hookworm. The probable source of these helminths is soil contamination. The second component has a high significant positive loading for *A. lumbricoides* only. The likely source of this factor is faecal-oral contamination.

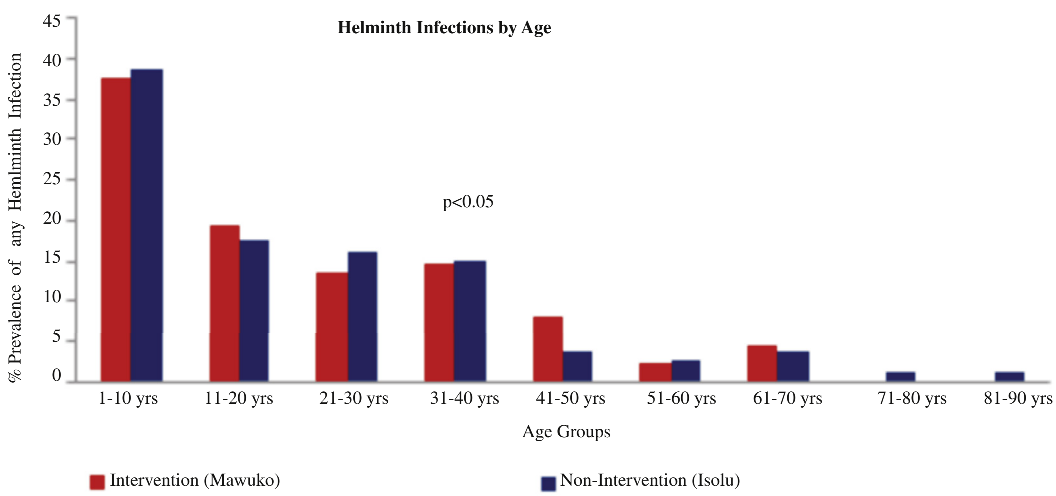

Figure 2. Prevalence of helminthiasis by age in intervention (Mawuko) and non-intervention (Isolu) communities.

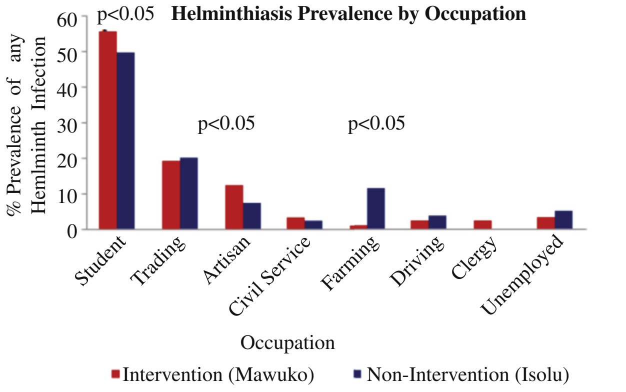

Figure 3. Prevalence of helminthiasis by occupation in intervention (Mawuko) and non-intervention (Isolu) communities.

Table 4

Principal component analysis of helminth infections.

Helminth infections	Component		Communalities
	1	2	
Hookworm	−0.949	0.069	0.906
Ascaris lumbricoides	0.049	0.943	0.891
Taenia sp.	−0.735	0.391	0.693
Trichostrongylus sp.	0.910	0.381	0.974
Trichuris trichiura	0.993	−0.070	0.990
Strongyloides stercoralis	0.910	0.381	0.974
Hymenoplesis nana	0.993	−0.070	0.990
Multiple infections	−0.963	0.257	0.906
% Variance	74.1	18.5	92.6
Source	Soil contamination	Fecal–Oral	

3.3. Assessment of helminth infections and sanitation

Table 5a and 5b showed the helminth infections by toilet facilities in the two study areas. Bush defecation showed the highest infections of hookworm (14%) while pit latrine was linked mostly to *Ascaris* infection. Cases of multiple infections were observed highest for bush defecation (26%). Bush defecation showed the highest infections of all the helminths identified in the study area. Water closet toilet showed zero prevalence for most of the observed helminths except *Ascaris*. At both sites, cases of polyparasitism were observed highest from respondents that use bush for defecation. Prevalence of helminths by toilet facilities was compared between the intervention and non-intervention communities. The users of bush as a mean of defecation have higher prevalence of helminth infections ($p < 0.05$) at the non-intervention site than those of intervention community. Higher prevalence value ($p < 0.05$) was also observed for users of pit latrine in Isolu than Mawuko. Helminth infections were generally higher at the intervention sampling site.

3.4. Effect of attitudes and practices on helminth infections in WASH intervention and non-intervention communities

Table 6 revealed the level of respondents' attitudes and practices in relation to sanitation. Data revealed low disposition of respondents to basic sanitation and hygiene at both the intervention and non-intervention sites. Bush defecation was widely practiced at the two communities. Despite the intervention programme of WASH, less than 40% of the respondents believed in the effectiveness of the programme. This might have resulted into large numbers of respondents who were ignorant about water-borne worms. The majority of the respondents were using water for anal cleaning and more than 60% washed their hands regularly with water only while only 50% of them cleaned their fingernails. Furthermore, only 7% of them treated their water before drinking. The only means of water treatment was alum coagulation. Close to half of the respondents also walked barefoot. These highlighted risk factors were the main reasons for high infection rate at both sampling sites. The response to personal hygiene on hand-washing was clearly high before and after meal (B/A), showing 59% at Mawuko and 54% at Isolu. The material for hand-washing was mainly water with few respondents using soap. The study also found that only 37% and 22% of the respondents had used deworming drugs in the last 6 months in Mawuko and Isolu, respectively. Despite the response of some of the respondents to periodic dose of anti-helminthic drugs, helminth infections were still high due to poor sanitation and hygiene.

Table 5a

Prevalence of helminthiasis by toilet facilities. Intervention community (Mawuko).

	Hookworm (%)	*Ascaris* (%)	*Taenia* (%)	*Trichostrongylus* (%)	Multiple infections (%)
Water closet	9	6	2	0	10
Pit latrine	5	8	0	0	13
Bush defecation	14	3	3	1	26
p-Value	0.000	0.008	0.011		0.000

Table 5b

Prevalence of helminthiasis by toilet facilities. Non-intervention community (Isolu).

	Hookworm (%)	*Ascaris* (%)	*Taenia* (%)	*Trichostrongylus* (%)	*Trichuris* (%)	*Strongyloides* (%)	*Hymenoplesis* (%)	Multiple infections (%)
Water closet	0	1	0	0	0	0	0	0
Pit latrine	10	4	0	0	0	1	0	19
Bush defecation	15	14	4	4	1	1	1	25
p-Value	0.000	0.000	0.001	0.001				0.000

Table 6

Effect of attitudes and practices on helminth infections.

	Mawuko (intervention community)				Isolu (non-intervention community)			
	Total no of respondents	No of yes	No of infected with at least one helminth	% Infected with at least one helminth	Total no of respondents	No of yes	No of infected with at least one helminth	% Infected with at least one helminth
On WASH	113	42	20	18	112	38	23	21
Water containing worms	113	39	35	31	112	63	16	14
Faeces containing worms	113	63	54	48	112	95	49	44
Anal cleaning-water	113	108	81	72	112	88	62	55
Anal cleaning-water & soap	113	5	4	4	112	3	6	2
Anal cleaning-tissue					112	14	9	8
Anal cleaning-water &leaf					112	7	5	4
Water treatment	113	10	8	7	112	10	8	7
Clean fingernails	113	59	44	39	112	59	35	31
Presence of footwear	113	65	49	43	112	57	35	31
Handwashing-B/A	113	113	46	41	112	61	32	29
Handwashing-A/D	113	113	2	2	112	5	2	2
Handwashing-R	113	113	35	31	112	38	22	20
Handwashing-S	113	113	3	3	112	6	2	2
Handwashing-A/M	113	113	3	3	112	0		
Materials for handwashing-water	113	113	81	72	112	107	75	67
Materials for handwashing-water & soap	113	113	7	6	112	5	3	3
Deworming tablet in last 6 months	113	113	40	32	112	25	19	17

B/A-before and after defecation, A/D-after defecation, R-regularly, S-seldom, A/M-after meal.

4. Discussion

The overall helminth prevalence values of 78% and 71% observed at the intervention and non-intervention communities, respectively were very high. The result showed a higher prevalence of infection at the intervention community despite the intervention programme of the UNICEF Water, Sanitation and Hygiene (WASH). The high prevalence of infections at both the study areas calls for public health concern taking into consideration of the ill-effects of helminths, especially on children. The intervention programme at Mawuko appeared not to be effective as a result of people's attitude. At the non-intervention community, the high prevalence of infection might be linked to lack of awareness of the WASH programme.

The high values of helminthiasis prevalence obtained in this study were higher than the values earlier reported in Abeokuta, Ogun State by Sam-Wobo *et al.* [19] and Akingbade *et al.* [23]. These research works have reported prevalence range of 6.6–25.8%. The lack of agreement in the helminths prevalence between this study and the previous studies in Abeokuta might be related to factors such as different sampling areas, types of ethnic groups in the study locations, disposition of individuals to hygiene and sanitation and ignorance [19]. Helminth infections in Ogun State has not declined despite the WASH intervention programme initiated by the UNICEF. The elevated helminthiasis prevalence observed in this study is comparable to Ugbomoiko *et al.* [24] study conducted in Oba Ile, Osun State who reported helminth prevalence of 95.7%. Other studies across Nigeria had reported prevalent values of helminths between 75% and 90% [25,26].

Hookworm was the most prevalent infection in this the study followed by *A. lumbricoides*, in contrary to observations of many studies conducted in the southwestern Nigeria where *A. lumbricoides* was found to be the most prevalent helminth [23,27,28]. The occurrence of hookworm as the highest prevalent helminth in this study is in line with some reported studies in the southeastern part of Nigeria. For example, Kamalu *et al.* [29] in their study in Owerri, Imo State observed hookworm as the highest prevalent helminth infection (16%). Wosu and Onyeabor [30] who carried out a study on the primary school students in Umuahia, Abia State reported higher prevalence of hookworm infection (34%) than the *Ascaris* (23%). Studies from northern part of Nigeria such as Biu *et al.* [31] and Babatunde *et al.* [32] also revealed higher prevalence of hookworm than the *A. lumbricoides*.

Taenia sp. (4% at Mawuko and 3% at Isolu) was the third most prevalent infection at the study area after *A. lumbricoides*. It should be noted that, in Isolu, *Trichostrongylus* had similar prevalence value as *Taenia* sp. Eating uncooked or partially cooked meat is the main route of *Taenia* infection. The earlier published work of Banjo *et al.* [27] had reported *Taenia* infection in the study carried out in Abeokuta metropolis. However, the prevalence value reported by Banjo *et al.* [27] was lower than the value obtained in this work due to reason that could be linked to different sampling locations [33] and/or levels of exposure [34]. A study conducted by Ejima and Ajogun [25] in Kogi State had reported high prevalence of *Taenia* infection.

The data collected for polyparasitism or multiple infections were high for ‘hookworm + *Ascaris*’ (20% at the intervention community and 14% at non-intervention community), and therefore represented a total of 43% in intervention community and 35% in non-intervention community. The high prevalence of ‘hookworm + *Ascaris*’, was in line with the study of Ugbomoiko *et al.* [24]. However, there were more helminth species co-existing together as multiple infections in this study when compared to the study of Ugbomoiko *et al.* [24]. It is possible that, *A. lumbricoides* infection would have ranked the most prevalent infection in this study, if the hookworm infection had not co-existed with it. The attitudes and dispositions of the local residents walking barefoot might have resulted into higher prevalence of hookworm than the *Ascaris*. Hookworm also co-existed with *Trichostrongylus* as the second most prevalent multiple infections. *Trichostrongylus* are usually contracted through faecal contaminated food and contact with herbivore faeces. This was evident by the daily cattle grazing activities by Fulani herdsmen across the two communities during the sample collection.

Gender analysis in relation to helminth infections established a significant association between the sexes; males showing higher level of exposure than their female counterparts in Mawuko while females were significantly higher in Isolu than their male counterparts. The domination of male in relation to exposure to helminth infections may be attributed to more levels of exposure through walking barefoot and playing football without footwears or playing with soil. In this study, males were more exposed to hookworm infections than females in the two study areas while females were more infected with *A. lumbricoides* similar to the research work of Ekpenyong *et al.* [34]. Females may be exposed to *A. lumbricoides* during activities such as cleaning the bums of their defecated children and washing of clothes containing faeces. It should be noted that the nursing mothers in these communities are poor and might not be able to afford the high cost of diapers for their babies. This might also suggest the reason why *A. lumbricoides* is most prevalent among the people of low socio-economic status [28,34].

The age group of 1–10 years was more infected with helminth infection than any other age group in agreement with many reported studies [35,36]. Children in this age group are usually exposed to high infection of helminths due to their activeness, playing barefoot, poor attitudes to hygiene and sanitation [24]. Apart from these factors, children immunity is yet to be fully developed against infections [37]. Data on the occupation versus helminth infections showed that students were the most infected subjects, followed by traders and artisans. The infected students and artisans were significantly higher ($p < 0.05$) in intervention community while infected farmers were statistically higher ($p < 0.05$) in non-intervention community probably due to the sampling size of the respondents at each location. Demographic data revealed that most of the students and artisans interviewed returned their stool samples in intervention community. This was also observed for farmers in non-intervention community. Studies have shown that students who were children of farmers were at the greater risk of intestinal parasites because they are improperly taking care of in terms of hygienic education [38]. Some studies have revealed farmers as the most infected for helminthiasis [29,39].

The respondents from the intervention community seemed to use water closet toilets compared to non-intervention community; however, the prevalence of helminthiasis was high at the two sampling locations because of low disposition to sanitation and hygiene. The WASH programme could have yielded better results at the intervention community if the respondents have incorporated right attitudes toward sanitation and hygiene. Prevalence by toilet facilities was significantly higher ($p < 0.05$) in Isolu for bush defecation and pit latrine. The finding of this present work is similar to the study of Saka *et al.* [40] in Ilorin, Kwara where prevalence of helminthiasis was high in respondents that wash hands only after eating and also without footwears.

In conclusion, this study revealed high prevalence of helminths in both study communities. The highest infections were observed for respondents using bush as a mean of defecation. The use of water for anal cleaning was also found to contribute to high incidence of infections. There is therefore, a necessity to re-vitalize the UNICEF WASH programme in Mawuko and then extend it to Isolu community. The awareness about the WASH programme could be extended to primary and secondary schools, because children are the most vulnerable to helminth infections. Finally, hygiene education should be incorporated into the curricular of primary and secondary schools.

Conflict of interest statement

We declare that we have no conflict of interest.

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