Parasitology Open

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A preliminary survey of school-based water, sanitation, hygiene (WASH) resources and soil-transmitted helminthiasis in eight public schools in Odeda LGA, Ogun State, Nigeria

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Research Article

Cite this article: Mogaji HO *et al* (2017). A preliminary survey of school-based water, sanitation, hygiene (WASH) resources and soil-transmitted helminthiasis in eight public schools in Odeda LGA, Ogun State, Nigeria. *Parasitology Open* **3**, e16, 1–10. https://doi.org/10.1017/pao.2017.18

Received: 8 April 2017
Revised: 21 July 2017
Accepted: 9 October 2017

Key words:
Nigeria; sanitation and Hygiene; *soil Transmitted Helminthiasis*; water

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Abstract

This cross-sectional study was undertaken to assess the status of school-based water, sanitation and hygiene (WASH) resources and soil-transmitted helminthiasis (STH) in Odeda, Ogun State, Nigeria. The status and condition of WASH resources were determined in eight selected schools (three with WASH support and five without). Stool samples were also collected from 428 pupils from both school categories and screened for STH infections. Findings showed that water and sanitation conditions of WASH resource programming schools were better than those in schools without WASH support. However, pupils' knowledge about STH infections and basic hygiene were not significantly different between both categories of school ($P > 0{\cdot}05$). The prevalence of Hookworm, Ascariasis and Trichuriasis cases recorded were 26·2, 18·2 and 1·6% respectively, with an overall prevalence of 33·4%. By school categories, Ascariasis (14·9 *vs* 20·6), Hookworm (17·7 *vs* 32·0), Trichuriasis (1·7 *vs* 1·6) and, any STH prevalence (27·4 *vs* 37·5) were recorded for schools with WASH resource programming and those without respectively. A greater portion of the infected children 95 (66·4%) were from schools without WASH support. Our findings imply that WASH resource may have very positive impact on the control of STH among school children. However, there is need for improvement on coverage, adequacy and maintenance of WASH facilities in school.

Introduction

Soil-transmitted helminthiasis (STH) is one of the commonest neglected tropical diseases (NTDs) worldwide and remains a public health problem in poor communities with enormous consequences for development (Tchuem Tchuenté *et al.* 2013). A recent analysis of NTDs in SSA (sub-Saharan Africa) identified Nigeria as a country with the greatest number of cases of STH infections (Hotez and Kamath, 2009) and ranked fourth or fifth globally behind China, India and Indonesia (DeSilva *et al.* 2003; Hotez and Ehrenberg, 2010; Lobo *et al.* 2011; Tchuem Tchuenté *et al.* 2013).

Ascaris lumbricoides (roundworm), *Trichuris trichiura* (whipworm), *Necator americanus* and *Ancylostoma duodenale* (Hookworms) are the commonest intestinal nematodes causing STH infection (WHO, 2012). It has been estimated that one-half of 181 million school-aged children (SAC) is infected with one or some combination of these intestinal nematodes (Brooker *et al.* 2006). Recently, it was predicted that about 5·7 million of the 41·5 million SAC in Nigeria are infected with any species of the STH, with an overall predicted prevalence of 13·8% (Oluwole *et al.* 2015). Infections have been shown to contribute to deleterious health such as anaemia, growth stunting, protein-calorie malnutrition, fatigue and poor cognitive development (Hotez *et al.* 2008). The World Health Organization therefore recommended annual or bi-annual deworming of school children for STH with prevalence cut-offs of 20 or 50% in endemic school populations, respectively (WHO, 2002). However, deworming has not been able to prevent re-infection, especially in heavily contaminated endemic areas (Jia *et al.* 2012). Therefore, the integration of STH control with the provision of water, sanitation and hygiene education interventions (WASH) is thus been promoted as a complementary strategy for the elimination of STH (Freeman *et al.* 2013).

WASH resource programming includes access to safe water, improved sanitation and good hygiene practices and education (Freeman *et al.* 2013). Implementation of WASH continues to gain momentum with increased commitment from governmental and non-governmental donors through the provision of funds and resources. UNICEF plays a leading role in providing access to potable water, improved sanitation and hygiene education in rural communities

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Table 1. List and characteristic of study schools

	Year of establishment	Settlement	Population	Male (%)	Female (%)
WASH resources programming school					
OLG primary school Alabata	1951	Rural	425	242 (57)	183 (43)
Baptist Day primary school Obete	1942	Rural	138	79 (57)	59 (43)
St. Saviours primary school Olugbo	1955	Urban	444	212 (48)	232 (52)
Non-WASH resources programming school					
St. Mary primary school Osiele	1885	Urban	628	293 (47)	335 (53)
Community primary school Aaya	1982	Rural	196	89 (45)	107 (55)
OLG primary school Obantoko	1955	Urban	915	466 (51)	449 (49)
St. James primary school Orile	1934	Urban	492	265 (54)	227 (46)
St. Anthony primary school Ijemo	1948	Rural	245	128 (52)	117 (48)
Total			3483	1774	1709

and schools in Nigeria. This project commenced about a decade ago in Ogun State, due to lack of potable water and poor sanitation. However, the coverage is not universal (UNICEF, 2008; Mogaji *et al.* 2016). The maintenance of these resources is also left in the hands of the community members or schools where it is situated. Till recent, reasonable impact assessment of WASH intervention on schooling children is yet to be undertaken in Nigeria. This study therefore assesses the school-based WASH programme and burden of STH infections among schooling children in southwest Nigeria.

Materials and methods

Study area and selection of schools

This survey was undertaken in eight public primary schools in Odeda area, near Abeokuta (the capital city) of Ogun State. Odeda is one of 20 administrative units in the State, and is the pilot unit for water, sanitation and hygiene resource programming. There were 106 public primary schools in the area in 2013. Study schools were selected using a stratified random sampling procedure. Schools were first categorized into two groups; those benefitting from WASH resource programming ($n = 3$) and those without ($n = 103$) (Mogaji *et al.* 2016). The three WASH resource programming school were purposively selected. The non-WASH resource programming schools were further stratified into five clusters based on proximity. Finally, random sampling was employed in the selection of a school per cluster. Eight primary schools were selected in total for the study (Table 1). Schools with WASH intervention had support from non-governmental organizations (i.e. UNICEF) in the provision of water pumps, toilet and urinal facilities and in some cases hand-washing facilities as compared with non-WASH resource programming schools. Since intervention was not randomized, this study was purely observational. The eight schools in the study were treated individually and not as clusters since they were not close to each other (Fig. 1). However, it is expected that children in the WASH resource programming schools would collectively depend on the provided WASH resource.

Selection of study participants

A total of 60 pupils per school were targeted for recruitment into the study, with a minimum number of 50 based on WHO guideline on survey for helminthiasis in schools (WHO, 2002). Selection of children in each school was carried out after stratification by their class grade from Primary 1 to 6. A quota was then allocated for each class grade with proportional allocation according to the number of students in each grade. Finally, the participating children were randomly selected. In schools where pupils were not up to 50 students, the entire pupils were encouraged to participate in the study. However, only 428 pupils consented to the study procedures and were recruited, hence giving roughly an unequal number of pupils selected across the schools.

Ethics statement

Ethical approval was granted by the ethical review board of Department of Public Health and Disease control, Ogun state Ministry of health. Permit to use the selected schools for sample collections were obtained from Ogun state Ministry of Education, Science and Technology and Ogun state Rural Water Supply and Sanitation Agency (RUWATSAN). Consent was sought and obtained from parents and guardians of the pupils after they were duly informed of the research. However, pupils oral consent was obtained verbally and documented on a child assent form. Participants were provided with single dose 400 mg albendazole treatment after the study.

Data collection

Three different survey field forms were used during the survey procedures for data collection. The pupil's form, the KAP form and the school form. The pupil's form was used to obtain each child's demographic information (name, date of birth, age and sex of the child). A questionnaire was administered on the children on Knowledge, Attitude and Practices (KAP) to obtain information on helminthiasis, sanitation, personal and environmental hygiene. A school form was used to assess the status and conditions of water, sanitation and hygiene. These include the type of water supply, number of water source, condition and type of latrines, number of latrines, latrines per population ratio, gender-segregated toilets, availability of soap for hand washing, and the presence of garbage piles around the school premises.

Determination of STH burden

A single stool sample was collected from each pupil, processed within 2 h after collection using sodium acetate-acetic acid formalin concentration method (SAF-ether) and examined for intestinal ova of STH. Two slides were prepared from 1 g of each stool sample

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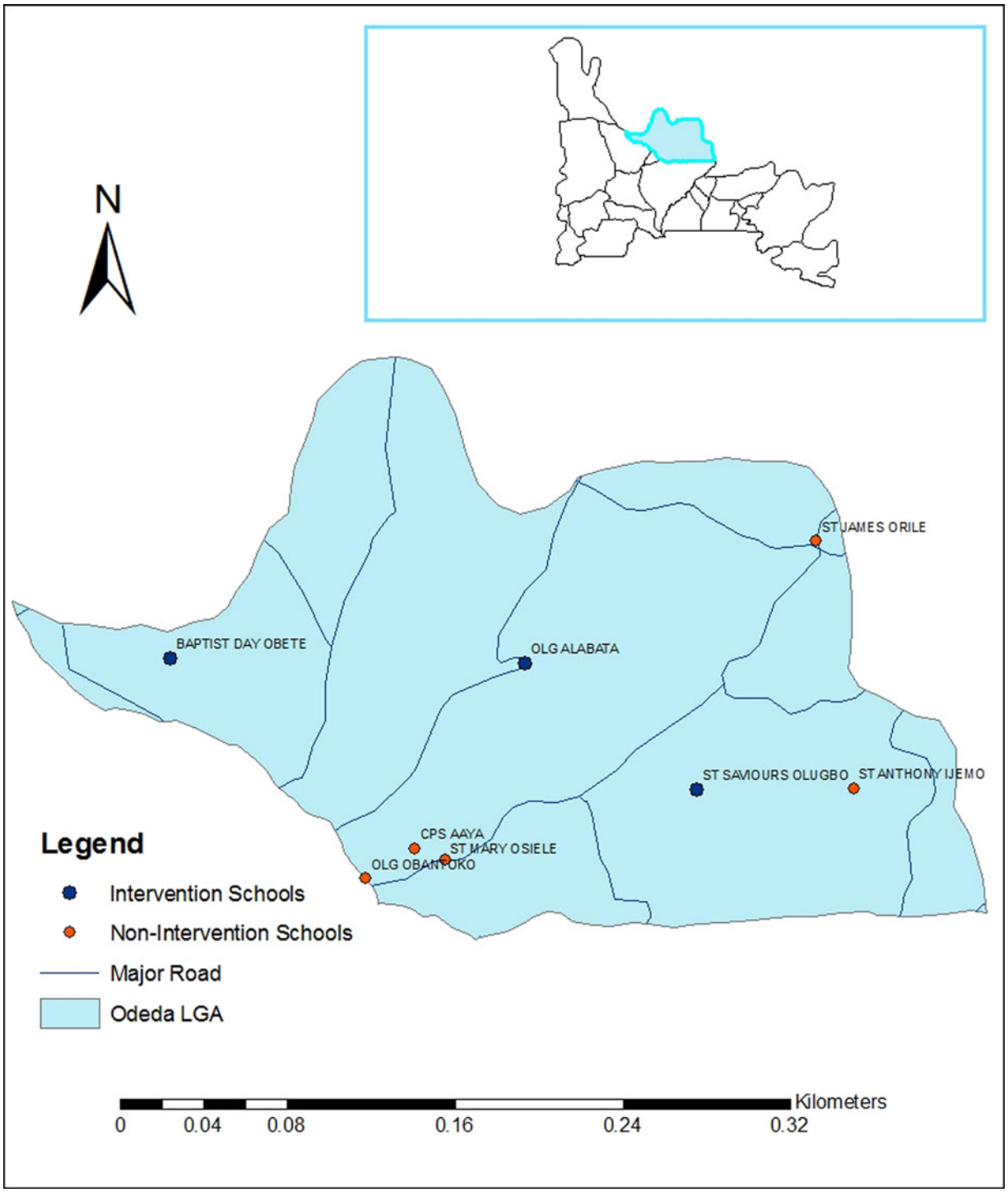

Fig. 1. Map of study schools.

collected for microscopy. Helminth eggs were counted for each species of STH, and the mean number of egg per gram (EPG) of stool was recorded for the examined person, from which the infection intensity estimate for the school was computed.

Scoring of status and condition of WASH resources

The type, conditions, adequacy and usage of water, sanitation and hygiene resource in both the WASH resource programming schools and non-WASH resource programming schools were assessed using a WHO/UNICEF recommended checklist for improved WASH interventions in schools (Adams *et al.* 2009). The status and condition of the WASH resources were carefully observed during field visitations and those that met the WHO/UNICEF set standards (i.e. improved conditions) were scored one point, while those that did not meet the set standards were scored zero or a negative point as appropriate. For each WASH resource component (i.e. water component, sanitation component and hygiene component), a cumulative test score was computed and used for comparison using chi-square (χ^2) statistics (Table 2).

Data analysis

Descriptive statistics were used to characterize the study population. The number of EPG of stool was transformed using log $(n+1)$ of raw count. The differences in prevalence and intensity

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of STH infections between WASH and non-WASH resource programming schools were determined using χ^2 statistics, *t*-test and analysis of variance, respectively. Significance was set at $P \leqslant 0{\cdot}05$.

Results

Demographic characteristics of the study schools

A total of 428 children aged 5–15 years were sampled in eight public primary schools that participated; 175 (40·9%) were from WASH resource programming schools and 253 (59·1%) were from schools without WASH support. A total of 226 (52·8%) were female and 202 (47·2%) were male, while 190 (44·4%) were within the age range 5–10 years and 238 (55·6%) were within the age range 11–15 years (Table 3).

Status and condition of safe water supply

All the WASH resources programming schools had functional hand pump boreholes. Two out of five (40·0%) of the non-WASH resource programming schools also had similar boreholes, though non-functioning. A cumulative score of 15 (100%) for safe water supply and conditions was recorded in WASH resource programming schools, whereas a cumulative score of 4 (16·0%) was recorded in the non-WASH resource programming schools. There was significant difference ($P < 0{\cdot}001$) in safe water supply between the two categories of school (Table 4).

Status and condition of sanitation

A total of 38 toilets were assessed, 19 (50%) each in both categories. Of the 38 toilets, only 25 (66%) were in use by the children in all the schools; 11 (44·0%) belonging to WASH resource programming schools and 14 (56·0%) in non-resource programming schools. In all the schools, only 13 (34·2%) of the toilets were clean (without foul odour or feces around the pit-hole) and they all belonged to non-resource programming schools. Although all the toilets in WASH resource programming schools were in use, but they were very dirty. There was a water closet system in two of the non-WASH resource programming schools in a dirty condition. There was no provision for soap and water for hand washing after toilet usage in both categories of schools. All toilet facilities were communal and not segregated by gender in all schools. The recommended estimated ratio of toilets to pupils' population were below WHO set standards (Table 5). A cumulative score of 8 (44·4%) was recorded for sanitation in the WASH resource programming schools, and a cumulative score of 6 (20·0%) was recorded in the non-WASH resource programming schools. The test scores for sanitation between WASH and non-WASH resource programming schools were not significantly different ($P = 0{\cdot}07$).

Status and condition of environmental hygiene resource

All the three WASH resource programming schools had garbage cans in their school premises. Whereas only one out of the five non-WASH resource programming school had garbage cans. Drinking water buckets with common drinking cups were absent

Table 2 Scoring template for assessing WASH status and conditions

WASH resource	Scores and Interpretation
Water component	
Water Source	Presence of improved water source, i.e. hand pump borehole = 1, Absence = 0
Number of water sources	Presence of at least one water source = 1, Absence = 0
Condition of water source	If water source is functioning = 1, if not = 0
Frequency of water supply	If water source is accessible all through the day = 1, if not = 0
Distance of water source	If water source is within the school premises = 1, if not = 0
Sanitation resource	
Number of available toilet	If pupil's enrolment to toilet hole is 50 : 1 = 1 if not = 0
No. of accessible toilets	If all toilets are accessible to pupils = 1 if not = 0
Toilet type in use	Presence of improved toilet facility, i.e. Sanplat, pit with lid, Flush toilet, etc. = 1, Absence = 0
Condition of toilet	Toilet without odour, flies or littering fecal materials = 1, Absence = 0
Soaps in toilet	Presence of soap in toilet = 1, Absence = 0
Toilets per pupil's population	If pupil's enrolment to toilet hole is 50 : 1 = 1 if not = 0
Toilets per gender	Presence of separate toilets for male and female = 1, Absence = 0
Presence of urinal facilities	Presence of urinal facility = 1, Absence = 0
Hygiene resource	
Presence of bushes	Presence of bushes = 0, Absence = 1
Presence of garbage can	Presence of garbage can = 1, Absence = 0
Presence of drinking water bucket with tap	Presence of water bucket with tap = 1, Absence = 0
Usage of common cup	Presence of common cups in classrooms = −1, Absence = 0
Presence of hand-washing facilities	Presence of hand-washing facilities = 1, Absence = 0
Presence of authorized food vendors	Presence of authorized vendors within school premises = 1, Absence = 0

0, Bad/Non-improved/Inadequate condition of WASH resource; 1, Good/Improved/Adequate condition of WASH resource; NA, Not applicable.

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Table 3. Demography of study participant across public primary schools surveyed

	Overall NE (%)	Sex		Age group	
		Male NE (%)	Female NE (%)	5–10 NE (%)	11–15 NE (%)
WASH resources programming school					
OLG primary school Alabata	55	31 (56·4)	24 (43·6)	21 (38·2)	34 (61·8)
Baptist Day primary school Obete	64	36 (56·2)	28 (48·8)	29 (45·3)	35 (54·7)
St. Saviours primary school Olugbo	56	27 (48·2)	29 (51·8)	21 (37·5)	35 (62·5)
Total	175 (40·9)	94 (53·7)	81 (46·3)	71 (40·6)	104 (59·4)
Non-WASH resources programming school					
St. Mary primary school Osiele	43	9 (20·9)	34 (79·1)	9 (20·9)	34 (79·1)
Community primary school Aaya	40	19 (47·5)	21 (52·5)	21 (52·5)	19 (47·5)
OLG primary school Obantoko	51	24 (47·1)	27 (52·9)	17 (33·3)	34 (66·7)
St. James primary school Orile	61	25 (41·0)	36 (59·0)	43 (70·5)	18 (29·5)
St. Anthony primary school Ijemo	58	31 (56·4)	27 (46·6)	29 (50·0)	29 (50·0)
Total	253 (59·1)	108 (42·7)	145 (57·3)	119 (47·0)	134 (53·0)
Grand total	428 (100)	202 (47·2)	226 (52·8)	190 (44·4)	238 (55·6)

NE, Number examined.

in the classrooms of all schools surveyed (Table 6). A negative scoring method was employed under the item 'usage of common cups'. This is simply because using common cups is not a good hygienic practice. So, if common cups were present in the classrooms, we deducted a point from their hygienic score (Table 6). The cumulative test score for the environmental hygiene of WASH resource programming schools was 11 (73·3%), while seven (26·9%) was recorded for non-WASH resources programming schools. There was a significant difference ($P = 0·004$) in the status and condition of environmental hygiene between the two categories.

School of knowledge, attitudes and practices

School children from non-WASH resource programming schools ($n = 120$, 47·4%) knew that human feces and water can harbour intestinal worms compared with children ($n = 69$, 39·4%) from WASH resource programming schools. However, this knowledge was not significantly different ($P = 0·1$) between groups (Fig. 2). Hygienic practices such as nail biting, finger sucking, pica and wearing of shoes differ in both group of schools. School children from non-WASH resources programming schools ($n = 84$, 33·2%) had more clean fingernails, which was significantly different ($P <$

Table 4. Water supply conditions of Study schools and Cummulative Test Scores

	Water source (test score)	Number of water source (test score)	Condition of water source (test score)	Frequency of water supply (test score)	Distance of water source (test score)	Total
WASH resources programming schools						
OLG primary school Alabata	Hand pump borehole (1·0)	One (1·0)	Functioning (1·0)	Daily (1·0)	<30 m (1·0)	5·0
Baptist Day primary school Obete	Hand pump borehole (1·0)	One (1·0)	Functioning (1·0)	Daily (1·0)	<30 m (1·0)	5·0
St. Saviours primary school Olugbo	Hand pump borehole (1·0)	One (1·0)	Functioning (1·0)	Daily (1·0)	<30 m (1·0)	5·0
Total						15 (100)
Non-WASH resources programming schools						
St. Mary primary school Osiele	Hand pump borehole (1·0)	One (1·0)	Not functioning (0·0)	None (0·0)	None (0·0)	2·0
Community primary school Aaya	None (0·0)	NA (0·0)	NA (0·0)	None (0·0)	None (0·0)	0·0
OLG primary school Obantoko	Hand pump borehole (1·0)	One (1·0)	Not functioning (0·0)	None (0·0)	None (0·0)	2·0
St. James primary school Orile	None (0·0)	NA (0·0)	NA (0·0)	None (0·0)	None (0·0)	0·0
St. Anthony primary school Ijemo	None (0·0)	NA (0·0)	NA (0·0)	None (0·0)	None (0·0)	0·0
Total						4 (16·0)

χ^2, df, P value = 10·8, 1, 0·000; Test score: 1·0, improved condition; 0·0, non-improved condition; NA, not applicable.

https://doi.org/10.1017/pao.2017.18 Published online by Cambridge University Press

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Table 5. Sanitation condition of study schools and cumulative test scores

	Number of toilets	No. of accessible toilets	Toilet type in use (test score)	Condition of toilet (test score)	Soaps in toilet (test score)	Toilets per pupil's population (test score)	Toilets per gender (test score)	Presence of urinal facilities (test score)	Total
WASH resources programming schools									
OLG primary school Alabata	6	2	Sanplat latrine (1·0)	Dirty (0·0)	None (0·0)	212 : 1 (0·0)	None (0·0)	Yes (1·0)	2·0
Baptist Day primary school Obete	6	6	Sanplat latrine (1·0)	Dirty (0·0)	None (0·0)	23 : 1 (1·0)	Yes (1·0)	Yes (1·0)	4·0
St. Saviours primary school Olugbo	7	3	Pit with Lid (1·0)	Dirty (0·0)	None (0·0)	148 : 1 (0·0)	None (0·0)	Yes (1·0)	2·0
Total	19 (50%)	11 (44%)							8 (44·4)
Non-WASH resources programming schools									
St. Mary primary school Osiele	6	4	Water closet (1·0)	Clean (1·0)	None (0·0)	157 : 1 (0·0)	Yes (1·0)	No (0·0)	3·0
Community primary school Aaya	2	1	Open pit (0·0)	Dirty (0·0)	None (0·0)	196 :1 (0·0)	None (0·0)	No (0·0)	0·0
OLG primary school Obantoko	4	3	Water closet (1·0)	Clean (1·0)	None (0·0)	305 : 1 (0·0)	None (0·0)	No (0·0)	2·0
St. James primary school Orile	3	2	Open pit (0·0)	Clean (1·0)	None (0·0)	246 : 1 (0·0)	None (0·0)	No (0·0)	1·0
St. Anthony primary school Ijemo	4	4	Open pit (0·0)	Dirty (0·0)	None (0·0)	61 : 1 (0·0)	None (0·0)	No (0·0)	0·0
Total	19 (50%)	14 (56%)							6 (20·0)
Overall total	38 (100%)	25 (100%)							

χ^2, df, *P* value = 3·3, 1, 0·07; Test score: 1·0, improved condition; 0·0, non-improved condition, NA, not applicable.

Table 6. Environmental hygiene condition of study schools and cumulative test scores

	Presence of bushes (test score)	Presence of garbage cans (test score)	Presence of drinking water bucket with tap (test score)	Usage of common cups (test score)	Presence of hand-washing facilities (test score)	Presence of authorized food vendors (test score)	Total
WASH resources programming schools							
OLG primary school Alabata	No (1·0)	Yes (1·0)	No (0·0)	NA (0·0)	Yes (1·0)	Yes (1·0)	4·0
Baptist Day primary school Obete	Yes (0·0)	Yes (1·0)	No (0·0)	NA (0·0)	Yes (1·0)	Yes (1·0)	3·0
St. Saviours primary school Olugbo	No (1·0)	Yes (1·0)	No (0·0)	NA (0·0)	Yes (1·0)	Yes (1·0)	4·0
Total							11 (73·3)
Non-WASH resources programming schools							
St. Mary primary school Osiele	No (1·0)	Yes (1·0)	None (0·0)	Yes (-1·0)	No (0·0)	Yes (1·0)	2·0
Community primary school Aaya	Yes (0·0)	No (0·0)	No (0·0)	NA (0·0)	No (0·0)	Yes (1·0)	1·0
OLG primary school Obantoko	No (1·0)	No (0·0)	No (0·0)	NA (0·0)	No (0·0)	Yes (1·0)	2·0
St. James primary school Orile	Yes (0·0)	No (0·0)	No (0·0)	NA (0·0)	No (0·0)	Yes (1·0)	1·0
St. Anthony primary school Ijemo	Yes (0·0)	No (0·0)	No (0·0)	NA (0·0)	No (0·0)	Yes (1·0)	1·0
Total							7 (26·9)

χ^2, df, *P* value = 8·3, 1, 0·004; Test score: 1·0, improved condition; 0·0, non-improved condition, NA, not applicable.

0·001) in comparison with school children ($n = 22$, 12·6%) from WASH resource programming schools. Pupils with trimmed fingernails were significantly more in the non-WASH resource programming schools ($n = 115$, 45·5%) compared to WASH resources programming schools ($n = 57$, 32·6%) ($P = 0·008$) (Fig. 3). Pupils who Bite and suck fingernails from WASH resource programming schools ($n = 84$, 48·0%) were significantly ($P = 0·04$) more than those from non-WASH resource programming schools ($n = 93$, 36·8%). Wearing of footwear was also a more common feature among children from non-WASH resource programming ($n = 214$, 84·6%) compared with children from WASH resource programming schools ($n = 95$, 54·3%). There was a significant statistical difference between the use of footwear by children and school categories ($P < 0·001$) (Fig. 3).

Prevalence and intensity of STH infections

A total of 143 (33·4%) of 428 children examined were infected with at least a species of STH. Prevalence of infection for

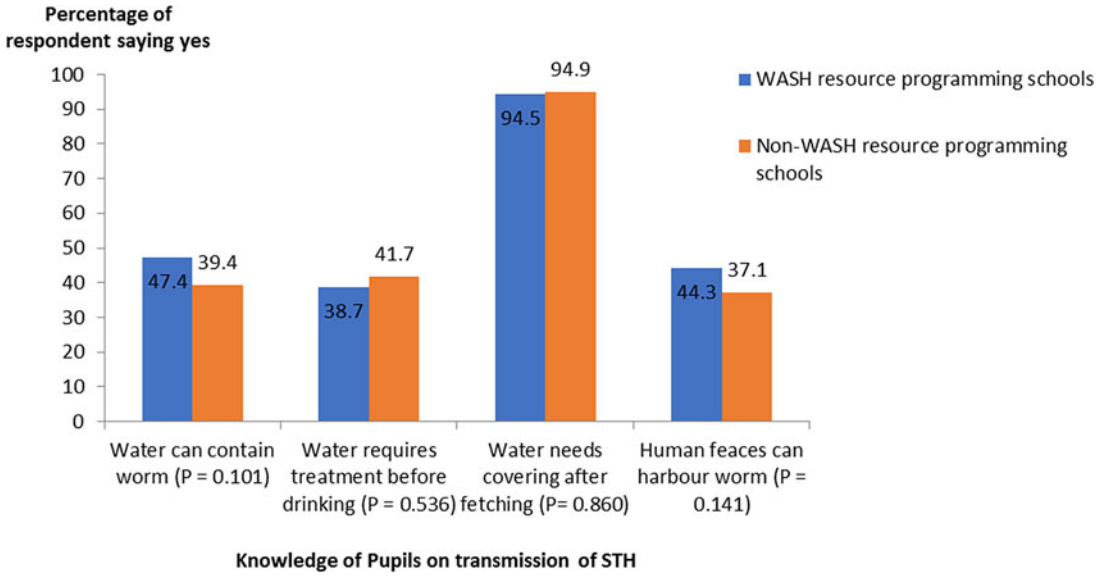

Fig. 2. Knowledge of study participants about transmission of STH infections.

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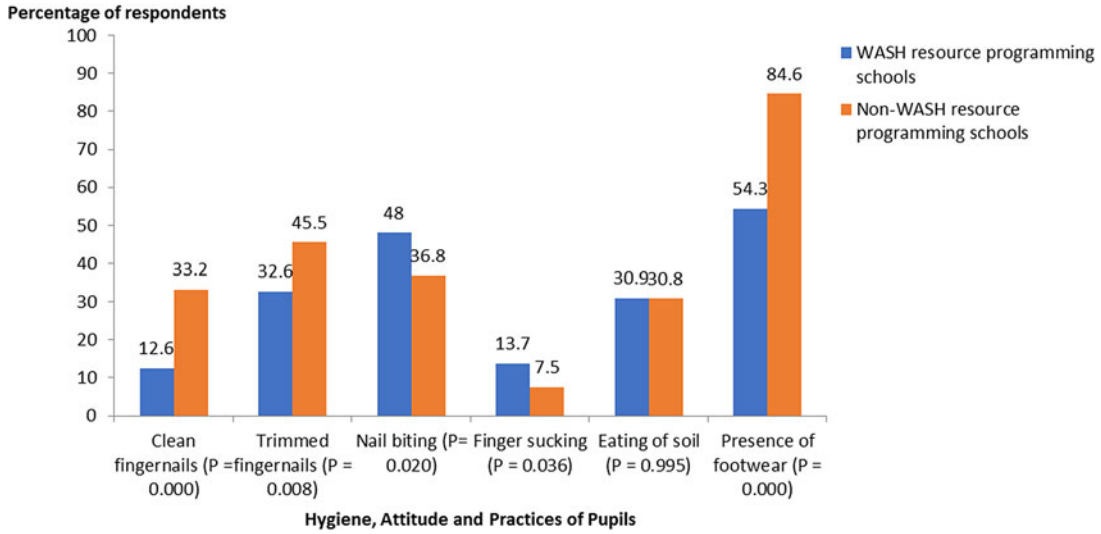

Fig. 3. Hygiene, attitudes and practices of study participant.

hookworms, *A. lumbricoides* and *T. trichiura* was 26·2, 18·2 and 1·6%, respectively. Comparison of STH prevalence between the two categories of schools revealed 37·5% in non-WASH resource programming schools compared with 27·4% in WASH resource programming schools. There was a significant difference in STH prevalence between the categories of studied schools ($P < 0·001$) (Table 7).

Ascaris lumbricoides mean infection intensities were higher in WASH resource programming schools (0·7237), compared with non-WASH resource programming schools (0·5497), although there was no significant difference ($P = 0·2$). Intensities of *Trichuriasis* (0·1193) and hookworm (0·6097) were higher in non-WASH resource programming schools compared with WASH resource programming schools. A significant difference ($P = 0·005$) was recorded for the intensity of hookworm infection between the school categories (Table 8).

Discussion

The overall prevalence reported for STH infection in this study reflects the status of helminthiasis morbidity in the study area, and reiterates the importance of complimenting school-based deworming activities with the provision of safe water, sanitation and hygiene resource (Freeman *et al.* 2013; Campbell *et al.* 2014). The lower prevalence of STH infections observed among pupils from WASH resources programming schools compared with those from non-WASH resource programming schools, further provides evidence to support the ongoing discussion that WASH resources may have secondary influence on the transmission of STH (Freeman *et al.* 2012, 2013; Ziegelbauer *et al.* 2012; Campbell *et al.* 2014). However, STH prevalence levels in WASH resourced schools are still above mandatory treatment levels (i.e. 20%). In fact, the highest intensity estimate for STH infection was recorded in one of the WASH resource schools. This is an indication of incessant transmission despite the availability of WASH resource. It is therefore reasonable that reduction in the transmission of STH among SAC cannot be achieved or sustained only by providing WASH resources. Inadequate numbers of latrines, limited accessibility and lack of maintenance by school management have been documented as factors that predisposes pupils to defecation on open grounds and nearby bushes (Xuan *et al.* 2012). It is therefore important to take into cognizance, issues of adequacy and maintenance of WASH resources to ensure sustained and effective intervention effect on STH transmission and control.

Despite the recommendation of WHO on '1 toilet hole for 50 male or 30 female pupils, respectively, only one out of the eight schools surveyed met the above recommendation (Adams *et al.* 2009). Also, not all available toilet facilities were accessible to the pupils, the clean and well-maintained ones were kept for the teachers. Segregating toilets per gender is therefore not feasible since toilets are inadequate and inaccessible to pupils. This indicates the need for more provision and maintenance of toilets in the public primary school's system. In addition, the consequences of poor sanitary conditions on hookworm transmission are well established; most especially in areas where wearing of footwear is not a common habit. Although the cumulative sanitation scores in the resourced and non-resourced schools appear to be equivalent, the non-WASH resourced schools had much greater percentage of children-wearing shoes (84%); yet, hookworm infection was much higher in non-resourced schools. Wearing of shoes by SAC is not a common habit in typical rural African communities. School children mostly wear shoes when they go to school and as well they pull them off while playing on school fields.

Water is a critical component of WASH resources. It is important for hand washing especially when soap is available. However, no soaps were seen in the schools surveyed. For non-WASH resource programming schools, water was not available in the school premises and pupils searched for water at locations outside the school premises, thus exposing themselves to infections transmitted through unsafe water sources (Lorna *et al.* 2005). Lack of access to safe water may have contributed to the high burden of STH infections recorded among children attending non-intervention schools. Furthermore, the scarcity of water resource or its inadequate quantity in non-WASH resource programming schools may not meet the WHO recommendation of 'at least 5 L of water' per children in day-schools. This may be a factor promoting transmission of STH when children engage in poor hygienic practices such as nail biting and finger sucking after using the toilets.

Finally, majority of the pupils were ignorant of the fact that water and human feces can harbour helminth's eggs. In fact, children from WASH resources programming schools were not better off in terms of knowledge when compared with their counterpart in non-WASH schools. This observation was unexpected and may be an indicator of the lack of poor hygiene and sanitation education in WASH resource programming schools. The higher

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Table 7. Prevalence of STH infections among the study participants

	NE	*Ascaris lumbricoides* NI (%)	*Trichuris trichiura* NI (%)	Hookworm NI (%)	Any STH NI (%)
WASH resources programming schools					
OLG primary school Alabata ($W=5$, $S=2$, $H=4$)	55	7 (12·7)	1 (1·8)	13 (23·6)	16 (29·1)
Baptist Day primary school Obete ($W=5$, $S=4$, $H=3$)	64	2 (3·1)	0 (0)	6 (9·4)	7 (10·9)
St. Saviours primary school Olugbo ($W=5$, $S=2$, $H=4$)	56	17 (30·4)	2 (3·6)	12 (21·4)	25 (44·6)
Total	175	26 (14·9)	3 (1·71)	31 (17·7)	48 (27·4)
χ^2, df, *P* value		17·8, 2, <0·001	4·9, 2, 0·03	2·3, 2, 0·09	17·2, 2, 0·000
Non-WASH resources programming schools					
St. Mary primary school Osiele ($W=2$, $S=3$, $H=2$)	43	19 (44·2)	3 (7·0)	24 (55·8)	26 (60·5)
Community primary school Aaya ($W=0$, $S=0$, $H=1$)	40	14 (35·0)	0 (0)	29 (72·5)	30 (75·0)
OLG primary school Obantoko ($W=2$, $S=2$, $H=2$)	51	3 (5·9)	0 (0)	10 (19·6)	12 (23·5)
St. James primary school Orile ($W=0$, $S=1$, $H=1$)	61	3 (4·9)	0 (0)	4 (6·6)	6 (9·8)
St. Anthony primary school Ijemo ($W=0$, $S=0$, $H=1$)	58	13 (22·4)	1 (1·7)	14 (24·1)	21 (36·2)
Total	253	52 (20·6)	4 (1·6)	81 (32·0)	95 (37·5)
χ^2, df, *P* value		35·8, 4, <0·001	10·5, 4, 0·03	64·7, 4, <0·001	57·9, 4, 0·000
Overall NE χ^2, df, *P* value	428	78 (18·2) 2·3, 1, 0·133	7 (1·6) 0·01,1, 0·915	112 (26·2) 10·9,1, 0·01	143 (33·4) 81,7, 0·000

W, Water cumulative score; S, Sanitation cumulative score; H, Hygiene cumulative score; NE, Number examined; NI, Number infected.

infection rates recorded in non-WASH resource programming schools despite their little knowledge about STH transmission reflects how insignificant the results of such knowledge could be on STH occurrence without WASH intervention. Effective hygiene education should be incorporated into the primary school curriculum, as this will help promote long-term positive behavioural changes among pupil both in school and at home (Jia *et al.* 2012; Nasr *et al.* 2013).

Table 8. Intensity of STH infections among the study participants

	Number Examined NE	*Ascaris lumbricoides* Mean log of EPG	*Trichuris trichiura* Mean log of EPG	*Hookworm* Mean log of EPG
WASH resources programming schools				
OLG primary school, Alabata	55	1·75[a]	0·02[a]	0·98[a]
Baptist Day primary school, Obete	64	0·38[a]	0·00[a]	0·16[a]
St. Saviours primary school, Olugbo	56	4·05[a]	0·04[a]	1·66[a]
Total	175	0·7237[a]	0·0000[a]	0·4247[a]
P value		0·080	0·326	0·063
Non-WASH resources programming schools				
St. Mary primary school, Osiele	43	0·3651[a]	0·000	0·6594[a]
Community primary school, Aaya	40	0·4832 [a]	–	0·7002[a]
OLG primary school, Obantoko	51	0·8521[a]	–	0·8295[b]
St. James primary school, Orile	61	0·2007[a]	–	0·4005[a]
St. Anthony primary school, Ijemo	58	0·9018[a]	0·4771	0·2402[a]
Total	253	0·5497[a]	0·1193[a]	0·6097[b]
P value		0·071	–	0·003
Overall F, df, *P* value	428	0·015, 76, 0·237	6·429, 5, 0·437	0·695, 110, 0·050

Mean values with same superscript across the same column are not significantly different at $P<0·05$, EPG: egg per gram of feces.

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Concluding remarks

Our study shows that there was a reduction in helminthiasis burden in schools benefitting from WASH resources compared with those schools not benefitting. However, these differences may also have been influenced by factors, such as the location of schools, soil type, precipitation, vegetation and temperature, which were not part of this study. Nevertheless, this study portrays the potentials of sustainable WASH resource programming implementation on reduction of morbidity and transmission of STH in public primary schools'.

Acknowledgements. We are grateful to the study participants who generously gave their time to be involved in this study.

Financial support. This work received financial support from TDR, the Special Programme for Research and Training in Tropical Diseases, co-sponsored by UNICEF, UNDP, the World Bank and WHO.

Conflict of interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

References

Adams J, Bartram J, Chartier Y and Sims J (2009) *Water, Sanitation and Hygiene Standards for Schools in Low Cost Settings*. Geneva, Switzerland: World Health Organization.

Brooker S, Clements ACA and Bundy DAP (2006) Global epidemiology, ecology, and control of soil-transmitted helminth infections. *Advances in Parasitology* **62**, 221–261.

Campbell SJ, Savage GB, Gray DJ, Atkinson JAM, SoaresMagalhães RJ, Nery SV, McCarthy JS, Velleman Y, Wicken JH, Traub RJ, Williams GM, Andrews RM and Clements ACA (2014) Water, sanitation, and hygiene (WASH): a critical component for sustainable soil-transmitted helminth and schistosomiasis control. *PLoS Neglected Tropical Diseases*, **8** (4), e2651.

DeSilva NR, Brooker S, Hotez PJ, Montresor A, Engels D and Savioli L (2003) Soil-transmitted helminth infections: updating the global picture. *Trends in Parasitology* **19**, 547–551.

Freeman MC, Greene LE, Dreibelbis R, Saboori S, Muga R, Brumback B and Rheingans R (2012) Assessing the impact of a school-based water treatment, hygiene and sanitation programme on pupil absence in Nyanza Province, Kenya: a cluster-randomized trial. *Tropical Medicine and International Health* **17**(3), 380–391.

Freeman MC, Ogden S, Jacobson J, Abbott D, Addiss DG, Amnie AG, Cairncross CBS, Callejas R, Colford JM, Emerson PM, Fenwick A, Fishman R, Gallo K, Grimes J, Karapetyan G, Keene B, Lammie PJ, MacArthur C, Lochery P, Petach H, Platt J, Prabasi S, Rosenboom JW, Roy S, Saywell D, Schechtman L, Tantri A, Velleman Y and Utzinger J (2013) Integration of water, sanitation, and hygiene for the prevention and control of neglected tropical diseases: a rationale for inter-sectoral collaboration. *PLoS Neglected Tropical Diseases* **7**, e2439.

Hotez PJ and Ehrenberg JP (2010) Escalating the global fight against neglected tropical diseases through interventions in the Asia Pacific region. *Advances in Parasitology* **72**, 31–53.

Hotez PJ and Kamath A (2009) Neglected tropical diseases in sub-Saharan Africa: review of their prevalence, distribution, and disease burden. *PLoS Neglected Tropical Diseases*, **3**, e412.

Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ and Jacobson J (2008) Helminth infections: the great neglected tropical diseases. *Journal of Clinical Investigation* **118**, 1311–1321.

Jia TW, Melville S, Utzinger J, King CH and Zhou XN (2012) Soil transmitted helminth reinfection after drug treatment: a systematic review and meta analysis. *PLoS Neglected Tropical Diseases* **6**, 1621.

Lobo DA, Velayudhan R, Chatterjee P, Kohli H and Hotez PJ (2011) The neglected tropical diseases of India and South Asia: review of their prevalence, distribution, and control or elimination. *PLoS Neglected Tropical Diseases* **5**, e1222.

Lorna F, Kaufmann RB, David K, Wayne E, Laurence H and John MC (2005) Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infectious Diseases* **5**, 42–52.

Mogaji HO, Adeaga DO, Yusuff QA, Johnson ME and Ekpo UF (2016) Preliminary evaluation of UNICEF's assisted water, sanitation and hygiene (WASH) programme using interview guides and spot checks in Ogun State, Nigeria. *Annual Research & Review in Biology* **9**(2), 1–7.

Nasr NA, Al-Mekhlafi HM, Ahmed A, Roslan MA and Bulgiba A (2013) Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 1: Prevalence and associated key factors. *Parasites & Vectors* **6**(27), 1–12.

Oluwole AS, Ekpo UF, Karagiannis-Voules DA, Abe EM, Olamiju FO, Isiyaku S, Okoronkwo C, Saka Y, Nebe OJ, Braide EI, Mafiana CF, Utzinger J and Vounatsou P (2015) Bayesian geostatistical model-based estimates of soil-transmitted helminth infection in Nigeria, including annual deworming requirements. *PLoS Neglected Tropical Diseases* **9**(4), e0003740.

Tchuem Tchuenté L, Noumedem CD, Ngassam P, Kenfack CM, Gipwe NF, Dankoni E, Tarini A and Zhang Y (2013) Mapping of schistosomiasis and soil-transmitted helminthiasis in the regions of Littoral, North-West, South and South-West Cameroon and recommendations for treatment. *BMC Infectious Diseases* **13**, 602.

UNICEF (2008) UNICEF WASH strategies paper. Water sanitation and hygiene. Available at http//www.unicef.org/.

WHO (2002) Prevention and control of schistosomiasis and soil-transmitted helminthiasis: report of a WHO expert committee. *World Health Organization Technical Report Series* **912**, 1–57.

WHO (2012) *Soil-transmitted Helminthiases: Eliminating Soil-Transmitted Helminthiases as A Public Health Problem in Children: Progress Report 2001– 2010 and Strategic Plan 2011–2020*. Geneva: World Health Organization. WHO/HTM/NTD/PCT/2012·4 WHO/HTM/NTD/PCT/2012·4.

Xuan LT, Hoat LN, Rheinlander T, Dalsgaard A and Konradsen F (2012) Sanitation behavior among schoolchildren in a multi-ethnic area of Northern rural Vietnam. *BMC Public Health* **12**, 140.

Ziegelbauer K, Speich B, Mäusezahl D, Bos R, Keiser J and Utzinger J (2012) Effect of sanitation on soil-transmitted helminth infection: systematic review and meta-analysis. *PLoS Medicine* **9**(1), e1001162. doi: 10.1371/journal.pmed. 1001162.

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