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Research paper

Analysis of Schistosomiasis and soil-transmitted helminths mixed infections among pupils in Enugu State, Nigeria: Implications for control

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Schistosomiasis;
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Abstract *Background:* Schistosomiasis and Soil-transmitted helminthiasis cause considerable morbidity and mortality in developing countries, especially among children. To this end it, a cross-sectional survey to determine the pattern of Schistosomiasis and Soil-transmitted helminthiasis co-infection was undertaken among primary school pupils in Oduma Community in Enugu State, Nigeria.
Methods: Fresh urine and stool samples were collected from pupils. The urine and stool samples were examined using sedimentation and Kat-Katz techniques respectively.
Results: Of the 236 pupils examined, 137 (58.1%) were found positive for at least one helminth infection. Ascaris lumbricoides was the most prevalent soil-transmitted helminth (STH), with a prevalence rate of 40.3%, followed by Trichuris trichiura (15.3%) and hookworm (8.9%). Infection with Schistosoma haematobium was detected in 13.6% of the pupils while Schistosoma mansoni infection prevalence was 7.2%. Age group 4 -7 years recorded the highest prevalence for S. haematobium, A. lumbricoides, T. Trichiura and hookworm infections. Multiple infections were also recorded, with 22.9% having double infections and 2.5% having triple infections. The most common double infection was A. lumbricoides with T. trichiura (8.9%), while the most common triple infection was A. lumbricoides, S. haematobium and hookworm (1.7%).
Conclusion: The results from the present study revealed an evident need for the systematic and sustained administration of school-based chemotherapy program targeting the control

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of STH infection and Schistosomiasis using Albendazole and Praziquantel respectively in the community, instead of a one-off approach that was carried out.

Highlights

- The overall prevalence rate of schistosomiasis and soil-transmitted helminth infections were 19.9% and 64.4% respectively.
- 58.1% of the pupils were found positive for at least either Schistosomiasis or soil-transmitted helminth infection.
- Mixed infection was observed in 11.0% of the school children.
- Overall, prevalence of infection was higher in males than in females for all Schistosoma and STH infections.

Introduction

Schistosomiasis and soil-transmitted helminthiasis (STH) are the most ubiquitous parasitic Neglected Tropical Diseases (NTDs) in the world. Schistosomiasis is caused by three species of blood-dwelling trematode parasites; *Schistosoma haematobium*, *Schistosomiasis mansoni* and *S. japonicum*. *S. haematobium* is responsible for urinary schistosomiasis while the other two species cause the intestinal form of the infection. The causative organism for soil-transmitted helminths (STHs) infection includes *Ascaris lumbricoides, Trichuris trichiura*, hookworms and *Strongyloides stercoralis*. Schistosomiasis and STHs are poverty-related and constitute a major source of morbidity and mortality for developing countries in Africa, South America, the Caribbean, the Middle East and Asia [1,2]. The burden of these helminth infections was formerly underestimated, but there is now a general consensus that STH and schistosomiasis represent an important public health problem especially for children [3]. A frequently reported morbidity of STH and schistosomiasis in young children is impaired cognitive development leading to poor educational outcomes [4,5]. Factors responsible for a high rate of STH in developing countries including Nigeria include poverty, poor environmental hygiene, improper waste disposal, inadequate water supply, gross environmental pollution and the constant pollution of the air and water bodies [2,6—8]. There have been several reports from various parts of Nigeria on STH, and these infections have been recognized as an important health problem especially among growing school-age children [7,9—14].

Schistosomiasis is the most prevalent NTD, and school-age children, adolescents and young adults account for the highest prevalence [15]. Useh [16] reported that approximately 779 million people are at risk of schistosomiasis, with 240 million being infected globally. Nigeria remains the country with the greatest number of people infected with schistosomiasis worldwide [17], with about 29 million infected people [18]. Specifically, many authors in Nigeria have variously reported that schistosomiasis occurs in school-age children around 5—20 years of age [19—22]. In Nigeria, schistosomiasis and STH infections continue to have a negative impact on the overall health status and fitness of school children. Infections often lead to iron deficiency anaemia, wasting, listlessness, diarrhoea and chronic pain [3,18,19], and also negatively affect attentiveness of school children [3].

The control of schistosomiasis and STH has become a concern for many governments and has the support of donors as international organizations following the World Health Assembly resolution in 2001 [23]. School-based deworming programmes using anthelminthics drugs is the adopted strategy for prevention and control of schistosomiasis and STH infections in school children [24]. Identification of communities where these infections co-exist, and the extent of their disease burden will facilitate control programmes required in the implementation of preventive chemotherapy treatment [25]. In Nigeria, earlier studies confirm that both schistosomiasis and STH infections are endemic in the country [9,12,20,26,27], however studies on their co-infection has been largely neglected. Oduma community possesses ecological features likely to promote schistosomiasis and STH infections. Furthermore, the Enugu State Ministry of Health has received several verbal reports through the health centres in Oduma about the incidence of schistosomiasis, and the ministry subsequently performed a one-off school-based chemotherapy for both schistosomiasis and STH infections using Albendazole and Praziquantel in June 2015. This study therefore seeks to analyse schistosomiasis and soil-transmitted helminths co-infection among pupils in Oduma community post chemotherapy. Moreover, the study will provide a reliable data for the Ministry of Health to evaluate the effectiveness of the chemotherapy exercise towards making effective decisions.

Methods

Study area

Oduma is a rural community in Aninri Local Government Area (LGA) of Enugu state in southeastern Nigeria. The town lies between longitude 7°35′ and 7°58′E of the Greenwich meridian and latitude 6°03′ and 6°05′N of the equator. It has an annual rainfall of about 1000 mm—1400 mm and temperature range of between 28 and 34 °C.

Oduma community is endowed with good arable land for agriculture hence the occupation is predominantly farming. The topography of the land is mainly low level, with the only hilly areas found in the south of the community. These hills are characterized by the Gburugburu and Iyiezi springs, which are the only source of drinking water in the community. School children use this body of water for recreational purposes. Farmers enter into the springs to collect water for irrigation purposes. About 60% of Oduma population earn their livelihood from the cultivation and marketing of rice, okra, pineapple, sugarcane, cucumber, yam and other farm produce [28].

Ethical consideration and permission to conduct study

Ethical clearance for the study was given by the Enugu State Ministry of Health after due consultation with the Local Government Education Authority in Aninri. In the primary schools, the headmasters gave their consent after which approval by the PTA (Parents and Teachers' Association) was also sought for and obtained through the head teachers. Parents and teachers were pre-informed on the need, procedure and purpose of the study. Pupils whose parents or guardians consented to their participation were included in the study.

Study population and sample size

This study was conducted between from April to July 2016. The total number of primary schools in Oduma community was eleven. Out of every three (3) schools closely located, one was randomly selected. The study population comprised pupils aged 4–15 years. The pupils were drawn from three (3) different primary schools namely Amagu Central School 1, Community School 1 and 2 Ezinesi and Community Primary school 1 and 2 Ukete. Amagu Central School 1 had a population of 226 pupils, Community School 1 and 2 Ezinesi had a population of 110 pupils, while Community Primary school 1 and 2 Ukete had population of 201 pupils. The total population of the three schools put together was 537. A sample size of 229 was determined using the methods of Suresh and Chandrashekara [29]. The selection of the pupils was done using simple random sampling technique. This was achieved by lining up the pupils in each school while each of them was given a consecutive number and selection made according to a specified sampling interval.

Specimen collection

A day before the collection of the stool and urine samples, each enrolled pupil was provided with two labelled sterile plastic containers each in order to provide urine and faeces samples together with an applicator stick and plain paper. The plastic containers bore a code number. The code of the container and the particulars (name, sex, age and class) of the participant were duly recorded. The participant was instructed to defecate on the paper provided in the morning of the next day to avoid contamination from the toilet environment, and using the applicator stick, pick up a portion of the stool that is about a thumbs' size and transfer it into the clean plastic container provided. On arrival to school that morning, the stool samples were immediately mixed with 10% formalin so as to preserve the morphology of the eggs. This was capped and sealed with paraffin film to prevent spillage and transported to the laboratory for analysis. Urine samples were obtained in school between 10:00 am to 2:00 pm, which is the peak time for egg release by the *Schistosoma* parasite. Prior to urine production, the participant was subjected to a little exercise to agitate their bladder. Approximately, thirty (30) mls of midstream urine was collected using the sterile pre-labelled containers. The collected samples were properly labelled and checked for visible haematuria before it was transported in ice packs to the laboratory for analysis.

Determination of infection with S. haematobium

Urine sedimentation technique as described by Cheesbrough [30] was used to determine the presence or absence of *S. haematobium* ova in samples. Briefly, 10 mls of urine was transferred into a test tube using disposable plastic pipette, and centrifuged at 1000 rpm for 5 min to concentrate eggs of *Schistosome*. After centrifugation, the supernatant was discarded while the pellet/sediment was transferred to a microscope slide and viewed using 10× and 40× objectives. The *S. haematobium* eggs were identified as having a rounded anterior end and the possession of a characteristic terminal spine from the tapered posterior end of the egg along with the aid of diagrams provided in Cheesbrough [30]. Intensity of the infection in each case was reported as the number of ova/10 ml of urine and was categorized as light infection (1–10 ova/10 ml), moderate infection (11–49 ova/10 ml) and heavy infection (>50 ova/10 ml). In addition, haematuria were screened using reagent test strips (Medi-test, Combi 9®) (Machery-Nagel, Germany) as described by the manufacturer. Briefly, the strip was dipped into 5 ml of urine sample in a clean test tube. The result was classified according to the corresponding colour shades and values for haematuria as negative (-ve; <10 mg) or positive (+; 30–100 mg, ++; 100–300 mg, +++; >300 mg). A positive control for haematuria was done by adding a drop of blood into 100 ml of sterile distilled water while the negative control was sterile deionized water.

Determination of STH and S. Mansoni infection

Determination of STH and S. *mansoni* infections was done using Kato-katz technique [31]. Briefly, 200 mg of the faecal material was transferred from the container and placed on a piece of newspaper. A piece of wire net screen was pressed on the top so that part of the faeces sieved through the screen and accumulated on top. A flat-sided spatula was scraped across the upper surface of the screen to collect the sieved out faeces. A standard template with a hole that can hold about 41.7 mg of faeces was placed on the slide and the sieved out faeces was transferred to completely fill the hole. The spatula was passed over the filled template to remove excess faeces from the edge of the hole. The template was then removed carefully so that a cylinder of faeces of about 41.7 mg was left on the slide. The cylinder of faeces was covered with a cellophane strip that was pre-soaked in malachite green solution. The slide was inverted and pressed firmly against the cellophane strip to spread evenly. The slide was then placed on a microscope slide rack and allowed to dry in room temperature. After a clearing time of 40—60 min, the slide was examined using a light microscope. The number of *A. lumbricoides*, *Trichuris trichuria*, hookworm and *S. mansoni* eggs were identified according to Chessbrough [30] and counted on a per-species basis. The egg per gram (epg) of stool value was indirectly obtained by multiplying the number of eggs counted on the slide by a fixed multiplication factor of 24 according to Katz et al., [31]. For quality control, a random sample of 5% of all slides was re-examined.

Analysis of data

Data obtained was entered and analysed using the Statistical Package for Social Sciences (SPSS) version 17 (SPSS Inc, Chicago, IL, USA). Chi-square test and analysis of variance (ANOVA) were performed to determine the association of age groups and gender with prevalence. Multiple linear regressions were utilized to determine the association of age and gender with prevalence of infection. The level of significance in all cases was set at 0.05.

Results

A total of 236 primary school pupils were enrolled (115 males and 121 females) in the study. The pupils were categorized into age groups 4—7years, 8—11years and 12—15years. All the pupils included in this study submitted both urine and stool samples.

Five (5) parasites were identified in stool and urine samples of pupils. They include *S. mansoni*, *A. lumbricoides*, hookworm and *T. trichiura* from stool and *S. haematobium* from urine.

Prevalence of Schistosomiasis

Of the 236 pupils sampled, 47 (19.9%) were positive for schistosomiasis (Table 1). The prevalence of *S. haematobium* infection was found to be 13.6% (32/236) and that of *S. mansoni* infection 7.2% (17/236). Age group 8—11 years recorded the highest prevalence of schistosomiasis with 21.8% while age group 12—15 years had the lowest prevalence of 15.9%. There was however no significant difference in the prevalence of schistosomiasis infection among the age groups ($\chi^2_{0.05} = 0.973$, df = 2, P = 0.615). The prevalence of *S. haematobium* infection was found to be highest among age group 4—7 years (16.7%) and least for pupils within age group 12—15 years (7.2%). The difference among the age groups for *S. haematobium* infection was not significant ($\chi^2_{0.05} = 3.339$, df = 2, P = 0.188). On the other hand, *S. mansoni* infection was found to be highest among age group 12—15 years (8.7%) and least for age group 8—11 years (5.9%). Similarly, the difference observed for *S. mansoni* infection between the age groups was not significant ($\chi^2_{0.05} = 0.484$, df = 2, P = 0.785). Male pupils recorded a higher prevalence rate of 21.7% for schistosomiasis while females had a prevalence of 18.2%. This difference was not statistically significant ($\chi^2_{0.05} = 0.468$, df = 1, P = 0.494). Female pupils showed a higher prevalence rate for *S. haematobium* infection (14.0%) compared to the males (13.0%). The observed difference was not statistically significant ($\chi^2_{0.05} = 0.051$, df = 1, P = 0.821). For *S. mansoni*, males were more infected (9.6%) compared to females (5.0%). The observed differences in both sexes were not significant ($\chi^2_{0.05} = 1.872$, df = 1, P = 0.171).

Prevalence of STH infections

For STH, 152 (64.4%) pupils were positive for infections. The STH parasites identified were *A. lumbricoides* 40.3% (95/236), *T. trichuria* 15.3% (36/236) and hookworm 8.9% (21/236) as presented in Table 2. There was significant difference between the prevalence of *A. lumbricoides* and *T. trichuria* ($\chi^2_{0.05} = 5.773$, df = 1, P = 0.016) and *A. lumbricoides* and hookworm ($\chi^2_{0.05} = 4.493$, df = 1, P = 0.034) while there was no significant difference between the prevalence of *T. trichuria* and hookworm infection ($\chi^2_{0.05} = 1.963$, df = 1, P = 0.161). The result also revealed that age group 4—7 years had the highest STH infection of 75.8% (50/66). The age group with the least prevalence was 12—15 years with a rate of 55.1% (38/69). There was however no significant difference in the prevalence of STH among the age groups ($\chi^2_{0.05} = 2.137$, df = 2, P = 0.344). The highest prevalence of STH infections of 81% was found to be among the males while females had a rate of 71% ($\chi^2_{0.05} = 3.312$, df = 1, P = 0.069). The differences observed in the prevalence rate of STH infections in relation to the sex of the pupils were not statistically significant ($P > 0.05$).

Schistosomiasis and STH co-infections

The prevalence rate of schistosomiasis and STH co-infection among the pupils was 11.0% (26/236). *S. haematobium* and *A. lumbricoides* co-infection with a prevalence rate of 3.8%

Table 1 Prevalence of Schistosomiasis among pupils of Oduma Community, Enugu State.

Age (years)	Number of samples			*S. haematobium* + ve (%)			*S. mansoni* + ve (%)			Schistosomiasis + ve (%)		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀	♂	♀	♂ + ♀	♂	♀	♂ + ♀
4—7	33	33	66	5 (15.2)	6 (18.2)	11 (16.7)	4 (121)	1 (3.0)	5 (7.6)	8 (24.2)	6 (18.2)	14 (21.2)
8—11	48	53	101	9 (18.8)	7 (13.2)	16 (15.8)	4 (8.3)	2 (3.8)	6 (5.9)	13 (27.1)	9 (17.0)	22 (21.8)
12—15	34	35	69	1 (2.9)	4 (11.4)	5 (7.2)	3 (8.8)	3 (8.6)	6 (8.7)	4 (11.8)	7 (20.0)	11 (15.9)
Total	**115**	**121**	**236**	**15 (13.0)**	**17 (14.0)**	**32 (13.6)**	**11 (9.6)**	**6 (5.0)**	**17 (7.2)**	**25 (21.7)**	**22 (18.2)**	**47 (19.9)**

Table 2 Prevalence of Soil-Transmitted helminths (STH) among pupils in Oduma Community, Enugu State.

Age (years)	Number of samples			*A. lumbricoides* + ve (%)			*T. trichiura* + ve (%)			Hookworm + ve (%)			STH + ve (%)		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀	♂	♀	♂ + ♀	♂	♀	♂ + ♀	♂	♀	♂ + ♀
4–7	33	33	66	16 (48.5)	14 (42.8)	30 (45.5)	4 (12.1)	7 (21.2)	11 (16.7)	6 (18.2)	3 (9.1)	9 (13.6)	26 (78.8)	24 (72.7)	50 (75.8)
8–11	48	53	101	23 (47.9)	15 (28.3)	38 (37.6)	6 (12.5)	9 (17.0)	15 (14.9)	5 (10.4)	6 (11.3)	11 (10.9)	34 (70.8)	30 (56.6)	64 (63.4)
12–15	34	35	69	14 (41.2)	13 (37.1)	27 (39.1)	6 (17.6)	4 (11.4)	10 (14.5)	1 (2.9)	0 (0.0)	1 (1.4)	21 (61.8)	17 (48.6)	38 (55.1)
Total	**115**	**121**	**236**	**53 (46.1)**	**42 (34.7)**	**95 (40.3)**	**16 (13.9)**	**20 (16.5)**	**36 (15.3)**	**12 (10.4)**	**9 (7.4)**	**21 (8.9)**	**81 (70.4)**	**71 (58.7)**	**152 (64.4)**

was the most common mixed infection encountered in the study (Table 3). Male children harboured a higher rate of schistosomiasis-STH co-infection of 11.2%, compared to female pupils that had a co-infection prevalence rate of 10.8%. The observed difference was however, not statistically significant at $P > 0.05$ ($\chi^2_{0.05} = 7.357$, df = 8, P = 0.499).

The prevalence rate by age for schistosomiasis-STH co-infection was highest in age group 8–11 years (12.9%) and least for age group 12–15 years (8.7%) as presented in Table 4. However, the observed difference was not statistically significant ($\chi^2_{0.05} = 16.839$, df = 16, P = 0.396).

Schistosomiasis-STH infection pattern among the schools studied

The prevalence of schistosomiasis-STH infections in relation to schools sampled showed that pupils from Community Primary School I and II Ukete recorded the highest prevalence rate of 71.6% (58/81), followed by Community School I and II Ezinesi which had a prevalence of 57.1% (36/63) and Amagu Central Primary School recorded the least prevalence rate of 46.7% (43/92) (Fig. 1). The observed differences in schistosomiasis-STH infections among the schools was statistically significant ($\chi^2_{0.05} = 10.966$, df = 2, P = 0.004). The prevalence of STH was highest in Community Primary School I and II Ukete [61.7%], and least at Amagu Central Primary School [39.1%] as presented in Fig. 1. The differences in the prevalence of STH among the schools was found to be statistically significant ($\chi^2_{0.05} = 8.804$, df = 2, P = 0.012). Also, it was found that Community Primary School I and II Ukete also had the highest prevalence of schistosomiasis infection of 30.0% (Fig. 1). The observed difference in the prevalence of schistosomiasis among the schools was also significant ($\chi^2_{0.05} = 9.533$, df = 2, P = 0.009).

The prevalence of the different parasitic infections studied in relation to schools in the study area revealed the following results: *A. lumbricoides* infection (45.7%), hookworm infection (17.3%) Trichuriasis (18.5%) was highest in Community Primary School I and II Ukete (Table 5). Amagu Central School recorded the least prevalence rate of 33.7%, 12% and 3.3% respectively for these infections. There was no significant difference in the prevalence of ascariasis and trichuriasis among the schools ($\chi^2_{0.05} = 2.814$, df = 2, P = 0.245; $\chi^2_{0.05} = 1.460$, df = 2, P = 0.482). However, the observed difference for hookworm infection among the schools was statistically significant ($\chi^2_{0.05} = 11.138$, df = 2, P = 0.004).

Community Primary School I and II Ukete also recorded the highest prevalence rate of 23.5% and 7.6% respectively for *S. haematobium* and *S. mansoni* infections (Table 5). The differences observed among the schools for prevalence of *S. haematobium* infection was highly significant ($\chi^2_{0.05} = 15.382$, df = 2, P = 0.000). Conversely, the observed difference for prevalence of *S. mansoni* infection was not statistically significant ($\chi^2_{0.05} = 0.835$, df = 2, P = 0.659).

Discussion

This study has confirmed the existence of schistosomiasis and soil-transmitted helminths co-infection among pupils in

Table 3 Prevalence of Schistosomiasis-STH co-infection by gender among pupils in Oduma Community, Enugu state.

Gender	Number of samples	Number infected (Prevalence in %)							
		Sh + Al positive	Sh + Tr positive	Sh + Hw positive	Sm + Al positive	Sm + Hw positive	Sh + Al + Tr positive	Sh + Sm + Al positive	Sh + Al + Hw positive
Male	115	6 (5.2)	0 (0.0)	2 (1.7)	2 (1.7)	1 (0.9)	0 (0.0)	0 (0.0)	2 (1.7)
Female	121	3 (2.5)	3 (2.5)	1 (0.8)	2 (1.7)	0 (0.0)	1 (0.8)	1 (0.8)	2 (1.7)
Total	**236**	**9 (3.8)**	**3 (1.3)**	**3 (1.3)**	**4 (1.7)**	**1 (0.4)**	**1 (0.4)**	**1 (0.4)**	**4 (1.7)**

Key: Sh = *S. haematobium*, Sm = *S. mansoni*, Al = *A. lumbricoides*, Tr = *T. trichiura*, Hw = Hookworms.

Table 4 Prevalence of Schistosomiasis-STH co-infection by age among pupils in Oduma Community, Enugu state.

Age (years)	Number of samples	Number infected (Prevalence in %)							
		Sh + Al positive	Sh + Tr positive	Sh + Hw positive	Sm + Al positive	Sm + Hw positive	Sh + Al + Tr positive	Sh + Sm + Al positive	Sh + Al + Hw positive
4—7	66	3 (4.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)	0 (0.0)	1 (1.5)	2 (3.0)
8—11	101	4 (4.0)	3 (3.0)	2 (2.0)	2 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.0)
12—15	69	2 (2.9)	0 (0.0)	1 (1.4)	2 (2.9)	0 (0.0)	1 (1.4)	0 (0.0)	0 (0.0)
Total	**236**	**9 (3.8)**	**3 (1.3)**	**3 (1.3)**	**4 (1.7)**	**1 (0.4)**	**1 (0.4)**	**1 (0.4)**	**4 (1.7)**

Keys: Sh = S. haematobium, Sm = S. mansoni, Al = A. lumbricoides, Tr = T. trichiura, Hw = Hookworms.

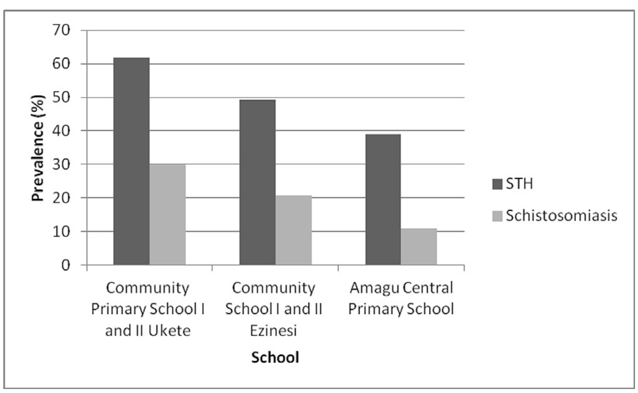

Figure 1 Prevalence of schistosomiasis-STH infections among schools in Oduma community, Enugu state.

Oduma community. These infections are known to impair productivity and learning in children as well as increase their susceptibility to other infections [32]. Previous studies in Africa have revealed that often, most parasitic diseases do not occur singly, but as mixed infections [32—34]. Therefore, co-infection of schistosomiasis and STH in the study area reveals co-endemicity and an overlap of conditions that favour co-existence of both infections.

S. haematobium infection has also been recorded in other communities in Enugu state, Nigeria. Ezeadila et al. [35] reported a prevalence of 5.5% in Amagunze community while a prevalence of 17.5% was observed in Obollo-eke community by Ogbonna et al. [20]. Other similar studies conducted in other parts of Nigeria reported similar results [36—38]. A higher prevalence rate of urinary schistosomiasis was recorded for females compared to males in this study, though the difference was not significant. This implies that both genders are at equal risk of infection in the community. However, some previous studies have indicated a higher prevalence among the male gender [39,40].

The high prevalence of STH reported in this study (49.6%) is similar to the results obtained by other researchers in Nigeria and other parts of Africa. Agbolade et al. [41] recorded a prevalence of 66.2% among school children in Ogun State Nigeria. Salawu et al. [26] reported a prevalence of 62.2% in a study conducted among school children in Saki town, Oyo State Nigeria. Abera et al. [33] observed a prevalence rate of 51.5% among primary school children in northwest Ethiopia. The high prevalence of STH recorded in this study may be

Table 5 Prevalence of individual parasites of Schistosomiasis and Soil-Transmitted helminths (STH) in relation to school in Oduma community.

Parasite	Community School I & II Ezinesi			Community Primary School I & II Ukete			Amagu Central School			Total
	Male	Female	n (%)	Male	Female	n (%)	Male	Female	n (%)	n (%)
A. lumbricoides	13	18	31 (33.7)	21	6	27 (42.9)	19	18	37 (45.7)	95 (40.3)
T. trichiura	5	6	11 (12.0)	7	3	10 (15.9)	4	11	15 (18.5)	36 (15.3)
Hookworm	0	3	3 (3.3)	4	0	4 (6.3)	8	6	14 (17.3)	21 (8.9)
S. mansoni	4	3	7 (7.6)	2	1	3 (4.8)	5	2	7 (8.6)	17 (7.2)
S. haematobium	1	2	3 (3.2)	6	4	10 (15.9)	8	11	19 (23.5)	32 (13.6)

attributed to the fact that most pupils practise open defecation in the nearby bushes surrounding the schools and their homes, which results in the parasite eggs being washed into the surrounding environment when it rains resulting in a contaminated environment. Moreover, the favourable climatic conditions such as high rainfalls, optimal temperature and a humid environment existing in this tropical environment encourage parasite survival.

A. lumbricoides had the highest prevalence rate among the pupils. This result is in agreement with the work done by Agbolade et al. [41] among school children in southwest Nigeria and the work done by Greenland et al. [42] among school children in Bihar State, India that reported prevalence rates of 53.4% and 52% respectively. The prevalence was higher in males (40.9%) than in females (40.5%) and was highest in 4—7 years age group. This could be attributed to the fact that males and younger children are most likely to come in contact with contaminated soil (because of their active behaviour), water, food, most do not practise proper hygiene (washing hand after defecation and before eating) which makes them prone to the infection.

The prevalence of *T. trichiura* was 15.3% and this rate was in contrast with the work done by Agbolade et al. [41] in Ogun state Nigeria where they reported a prevalence of 10.4%. However, it is somewhat similar to the result obtained by Salawu et al. [26] that reported a prevalence of 12.9% among school children in Oyo State, Nigeria. Females had a higher infection rate compared to the male pupils in this study. The probable explanation for the higher prevalence in females is that the girl-child is more exposed to potential domestic sources of transmission of *T. trichiura* infection during domestic chores such as food preparation, fetching water, cleaning the home and environment compared to their male counterpart. However, the influence of gender on prevalence of *T. trichiura* is inconclusive, as it may or may not play a role depending on regional and environmental factors and this requires further studies.

The prevalence of hookworm recorded among the pupils was 8.9%. This low prevalence rate is similar to that obtained in the study by Rwang et al. [34] among school children in Abia state Nigeria, who reported a prevalence of 3%. The low prevalence rate of hookworm infection reported in this study may have been affected by the method of analysis employed. Hookworm eggs are known to disintegrate rapidly and because Kato-katz slides require a clearing time of 45 min after preparation before examination, there is a very high tendency that most of the hookworm eggs might have undergone some degree of disintegration before the slides were read [43]. Hookworm infection was statistically significant among the age groups studied. Age group 4—7 years recorded the highest prevalence rate for hookworm infection. This may be attributed to the fact that most of the children within this age bracket prefer to go barefoot in and around the school and home surroundings which will expose them to the infection. Another factor could be due to lack of adequate toilet facilities which encourages them to defecate in bushes and open spaces.

Schistosomiasis-STH mixed infections showed that *S. haematobium* and *A. lumbricoides* co-infection was the most common mixed infection encountered in this study. This observation was in agreement with the work done by Salawu et al. [26] in Saki, Oyo State Nigeria. Studies conducted throughout Africa and China also indicate that most parasitic infections do not occur singly, but as co-infections [44,45] and this study is in agreement with this observation. The most common triple infection recorded in this study was a mixed infection of *S. haematoium*, *A. lumbricoides* and hookworm. This observation was in contrast with the works done by Agbolade et al. [41] and Salawu et al. [26] who reported ascariasis, hookworm and trichuriasis as the most common triple infection. Although co-infection between schistosomiasis and STHs was observed in this study, they were light infections. However such co-infection can readily affect morbidity as documented by Siza et al. [46] during their study of Schistosomiasis and STHs in lake Victoria Basin of Tanzania. They also noted that control of such NTDs could go on to become a powerful tool that can used to combat HIV/AIDS, tuberculosis and malaria. Similar findings of the effect of co-infection on morbidity were also reported by Midzi *et* al[9]and Rujeni et al. [47] in Zimbabwe and Rwanda respectively.

Pupils attending Community primary school I and II Ukete recorded the highest infection rate for both species of schistosomiasis. This can be attributed to the close proximity of this school to the stream which serves the community. This stream harbour snail intermediate hosts of schistosomiasis, and as such, pupils become infected when they visit the stream for recreational and/or domestic purposes. Furthermore, the soil condition of this village is swampy compared to that of other villages in the community. This condition is known to be favourable to breeding of fresh water snails [24—26]. Also worthy of note is the observed difference in the prevalence rate of schistosomiasis and STH among the schools studied. Pupils attending Community Primary School I and II Ukete were more infected than the other two schools put together, with the difference being statistically significant. The observed difference among the school can be associated with differences in macro- and micro-environment, environmental sanitation, and socio-economic status of the pupils, though follow-up studies will be required for clarification.

The present study provides information on a major health problem in Oduma community-a high prevalence and co-endemicity of schistosomiasis and STH. Further research is required to consider suitable intervention strategies such as improved consistent deworming exercise, provision of improved sources of water, sanitation and hygiene, health education and integrated sewage management system in the community.

Ethics and permission to conduct the study

Ethical approval for the study was obtained from the Enugu State Ministry of Health. Permission was also obtained from the Local Government Education Authority in Aninri and head of schools. Informed consent was obtained from parents or guardians of the school pupils after they were meant to understand the procedures, benefit and any risk of participation in the study.

Authorship statement

DA, SB and TY conceptualized the study. All the authors participated in the design and execution of the study. DB, SB, OA, SS and IU analysed the data. All authors contributed to the revision and approval of the final manuscript.

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Conflicts of interest

The authors declare no conflict of interest.

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