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Intestinal schistosomiasis in an apparently healthy rural population in Bayelsa State, Nigeria

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Abstract:

Background: Schistosomiasis is endemic in Nigeria and three species; *Schistosoma haematobium, Schistosoma mansoni,* and *Schistosoma intercalatum* have been reported in Niger Delta, Nigeria. This study aimed to determine the prevalence of schistosomiasis in rural communities of Bayelsa State, Nigeria.
Methodology: Four rural homogeneous communities; Otuegala, Immiringi, Otuesega, and Ibelebiri in Ogbia Local Government Area of Bayelsa State, Nigeria, were randomly selected for the study. A structured questionnaire was administered to each participant in their native language and used to collect participant's biodata and swimming history. Stool samples collected from all participants were examined qualitatively by wet preparation and after formol-ethol concentration. Data were analyzed using SPSS version 20.0 software and results presented in proportion and tables.
Results: A total of 829 participants (age range 1 - 80 years) were recruited for the study. Helminth ova were identified in the stool samples of 218 (26.3%) participants. Among 380 males examined, 82 (21.6%) were infected, while out of 449 females examined, 138 (30.3%) were infected. The ova of seven helminths identified and their frequency of occurrence were; *S. intercalatum* 86 (10.4%), *Ascaris lumbricoides* 53 (6.4%), *S. mansoni* 35 (4.2%), *Trichuris trichiura* 22 (2.6%), hookworm 20 (2.4%) and *Taenia* spp 2 (0.2%). *Schistosoma haematobium* was identified in non-urine contaminated stool sample of an eight-year old boy. A total of 11 (1.3%) participants had double infections, affecting 7 (63.6%) females and 4 (36.4%) males, with the commonest combination being *S. intercalatum* and *A. lumbricoides* 6 (0.7%), followed by *S. intercalatum* and hookworm 4 (0.5%), and *S. mansoni* and hookworm 1 (0.1%).
Conclusion: *S. intercalatum* was the most prevalent intestinal helminthic infection in this study, which is a rare finding in most epidemiological investigations. The affinity of *Schistosoma* species to establish double infections with hookworm and other intestinal helminths should be taken into account during chemoprophylaxis.

Keywords: Schistosomiasis, Chemoprophylaxis, Prevalence, Rural Population

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Schistosomiase intestinale dans une population rurale apparemment en bonne santé dans l'État de Bayelsa, Nigéria

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Abstrait:

Contexte: La schistosomiase est endémique au Nigeria et dans trois espèces; *Schistosoma haematobium*, *Schistosoma mansoni* et *Schistosoma intercalatum* ont été signalés dans le delta du Niger, au Nigeria. Cette étude visait à déterminer la prévalence de la schistosomiase dans les communautés rurales de l'État de Bayelsa, au Nigéria.
Méthodologie: Quatre communautés rurales homogènes; Otuegala, Immiringi, Otuesega et Ibelebiri dans la zone de gouvernement local d'Ogbia de l'État de Bayelsa, au Nigéria, ont été sélectionnés au hasard pour l'étude. Un questionnaire structuré a été administré à chaque participant dans sa langue maternelle et utilisé pour recueillir les données biographiques et l'histoire de la natation des participants. Les échantillons de selles prélevés sur tous les participants ont été examinés qualitativement par préparation humide et après concentration de formol-éthol. Les données ont été analysées à l'aide du logiciel SPSS version 20.0 et les résultats ont été présentés sous forme de proportions et de tableaux.
Résultats: Un total de 829 participants (tranche d'âge 1 - 80 ans) ont été recrutés pour l'étude. Des ovules d'helminthes ont été identifiés dans les échantillons de selles de 218 participants (26,3%). Sur 380 hommes examinés, 82 (21,6%) étaient infectés, tandis que sur 449 femmes examinées, 138 (30,3%) étaient infectées. Les ovules de sept helminthes identifiés et leur fréquence d'apparition étaient; *S. intercalatum* 86 (10,4%), *Ascaris lumbricoides* 53 (6,4%), *S. mansoni* 35 (4,2%), *Trichuris trichiura* 22 (2,6%), ankylostome 20 (2,4%) et *Taenia* spp 2 (0,2%). *Schistosoma haematobium* a été identifié dans un échantillon de selles non contaminé par l'urine d'un garçon de huit ans. Un total de 11 participants (1,3%) ont eu une double infection, touchant 7 femmes (63,6%) et 4 hommes (36,4%), la combinaison la plus courante étant *S. intercalatum* et *A. lumbricoides* 6 (0,7%), suivis de *S. intercalatum* et ankylostome 4 (0,5%), et *S. mansoni* et ankylostome 1 (0,1%).
Conclusion: *S. intercalatum* était l'infection helminthique intestinale la plus répandue dans cette étude, ce qui est une découverte rare dans la plupart des enquêtes épidémiologiques. L'affinité des espèces de Schistosoma pour établir des doubles infections par l'ankylostome et d'autres helminthes intestinaux doit être prise en compte au cours de la chimioprophylaxie.

Mots clés: schistosomiase, chimioprophylaxie, prévalence, population rurale

Introduction:

Schistosomiasis is a parasitic disease caused by blood fluke of the genus *Schistosoma* (1). In humans, the infection of schistosomiasis outranks all parasitic diseases except malaria, causing great morbidity with profound economic and public health importance (2). The disease exists in two forms; urogenital schistosomiasis caused by *S. haematobium* and intestinal schistosomiasis caused by four species: *Schistosoma mansoni*, *S. mekongi*, *S. japonicum*, and *S. intercalatum* (3). However, *S. mansoni* is the most widely distributed in endemicity and is found in sub-Saharan Africa, the Middle East, and Latin America. *Schistosoma intercalatum* is endemic in the rainforest area of Sao Tome and Equatorial Guinea and in the Central Africa Republic (4). *Schistosoma mekongi* and *S. japonicum* are found in China, the Philippines, and Cambodia districts, while in Africa, *S. mansoni* and *S. intercalatum* are the most prevalent species of intestinal schistosomiasis (5). *Schistosoma intercalatum* causes human rectal schistosomiasis in Africa (4) and has been associated with clinical non-typhoidal salmonella (NTS) septicaemia in children (6). Additionally, *S. mansoni* infection causes bloody diarrhea (7).

In Nigeria, both urinary and intestinal schistosomiasis are endemic but the degree of endemicity is low (8). *Schistosoma haematobium* is the most widely distributed species in Nigeria with 79.8% area coverage. All three species; *S. haematobium*, *S. mansoni*, and *S. intercalatum* known in Nigeria have been reported in the southern part of the country (9). According to epidemiological reports, most transmission sites of intestinal schistosomiasis were an agrarian settlement and among people living along water bodies (2).

The vegetations in Bayelsa State, Nigeria is that of freshwater swamps and lowland rain forest in most areas, which creates an ideal transmission site for schistosomiasis. In light of this, over the past 10 years, there have been continuous community-based health intervention programs targeted at prevention and control of infectious diseases and soil-transmitted helminths in the State. We, therefore, conducted this study with the intention to have better understanding of the prevalence of schistosomiasis and soil-transmitted helminthic infections in Bayelsa State.

Materials and methods:

Study setting:

The study was conducted in four rural communities located along the bank of Kolo Creek, within latitude/longitude N04.74960 E00 639553/N04.93480 E00 641840, in Ogbia Local Government Area of Bayelsa State. In the study areas are eutrophic water bodies and several inbuilt and natural factors in the environment that can sustain the transmission of intestinal helminths. These include absence of pit latrines and water closet system, culture of defaecating in the bush and into the creek water as well as the presence of freshwater swamps, lowland rain forest vegetation with much clay soil such that a greater part of the land is flooded during the rainy season. The inhabitants are peasant farmers, who are into fish and crop farming.

Both children and adults recreate in the creek and the stagnant pool of water, which also serve the purpose for washing of clothes, dishes and in some cases, for drinking. There are many freshwater snails in the water bodies in the neighborhood (Plate 1 & 2). Although rain falls every month of the year, the heavy downpour is typical of the tropical rain forest belt during the raining season (April-October).

Bayelsa State generally has the heaviest rainfall density in Nigeria with a short dry season (from November to March). It has a uniform mean annual temperature ranging from 25°C to 31°C throughout the year. The relative humidity is usually high and slightly higher during the rainy season (11).

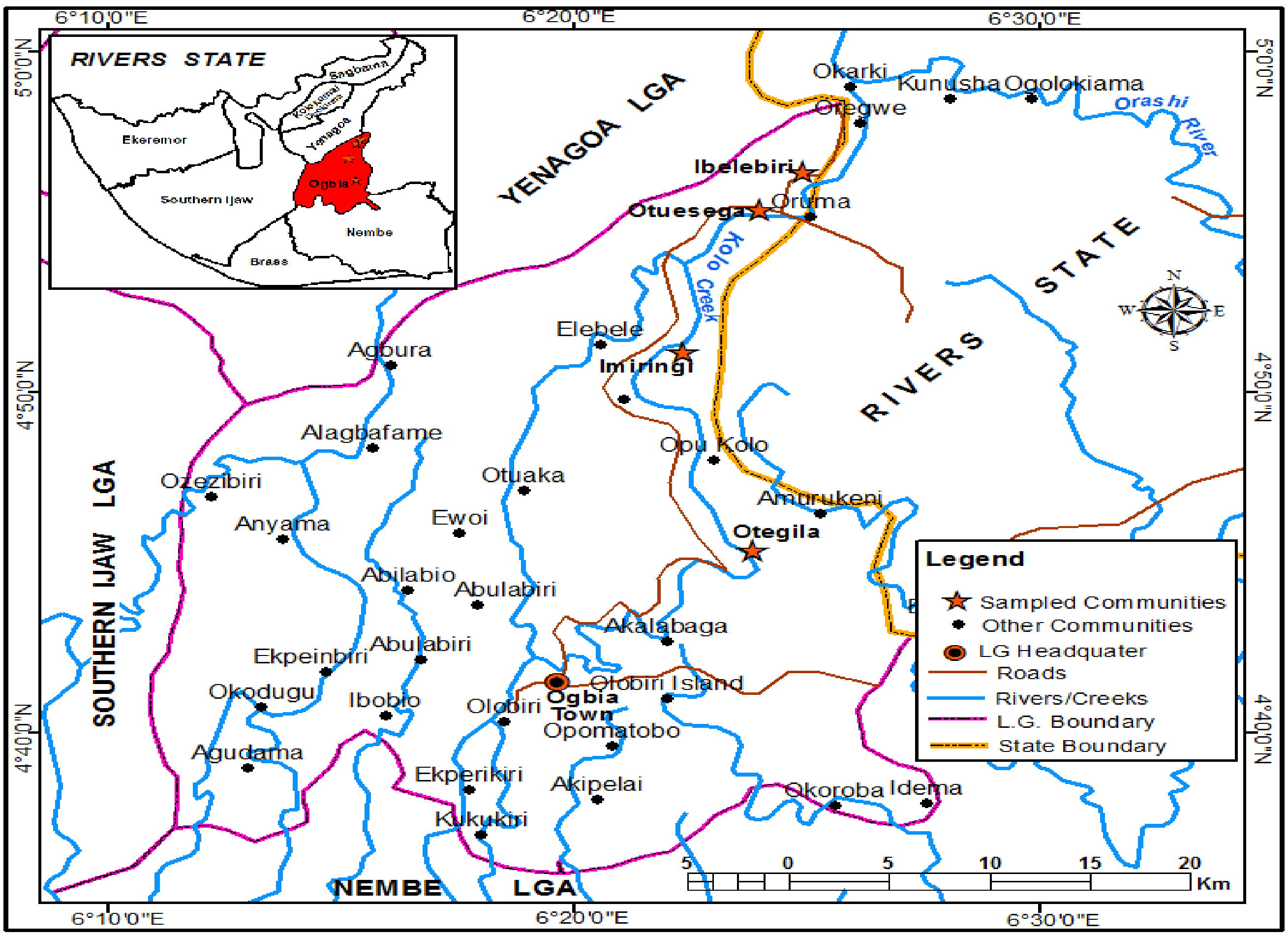

Fig 1: Ogbia Local Government Area Showing Sampled Communities
(Adapted from Mapsandmap.com, 2017)

PLATE 1: Swimming activities in a stagnant pool in Ibelebiri Community.

PHOTO CREDIT: Odoya

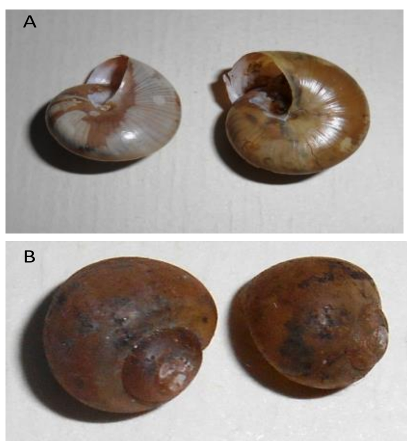

Plate 2. Snail vectors of schistosomiasis in the study locations.
A. *Biomphalaria* sp.; B. *Bulinus* sp.

Study population and subject participants

The study was cross-sectional in design and was conducted between May and June 2018. A simple random sampling technique (10) was used to select four out of the eleven communities in the Kolo district, and these were Ibelebiri, Otuesega, Otuegala, and Immiringi. All apparently healthy volunteers 4-80 years of age who had lived in the selected communities for more than three months were voluntarily enrolled into the study. Pregnant women and children less than four years of age were excluded.

Sample size determination

The sample size (n) was determined using the statistical formula, $n = z^2 p (1-p)/d^2$ (10), where n = minimal sample size, z = confidence level of 95% (standard value is 1.96), p = expected prevalence 50%, and d = margin of error of 5% (11). The final sample size was multiplied by a design effect of 2 due to the randomization technique used in community selection (12). Additionally, due to an expected attrition rate of 5%, the final sample size was adjusted to 808, but 829 participants were recruited.

Ethical approval

Ethical approval was obtained from the Ethics Committee, College of Medicine, University of Benin, Benin City, Edo State, Nigeria, and the Ministry of Health, Bayelsa State. Approval of leaders of the four communities was obtained as well as informed consent of each participant or parents/guardians of children.

Data collection and questionnaire administration

A structured questionnaire was administered to each participant in their native language and responses were appropriately marked in the given boxes. The information in the questionnaire included age, gender, history of swimming, fishing, and recreation in water bodies in the neighborhood.

Sample collection and laboratory examination of stool

A clearly labeled container and clear instruction on the process for collecting stool samples were provided for each subject participant. Participants were instructed to pass faeces on spread-out paper and with a spatula collect about a quarter filled faeces into the container. Stool samples were immediately fixed with 10% formalin, and sent to the postgraduate laboratory of the Department of Animal and Environmental Biology, University of Benin for analysis.

The examination of helminthes ova was qualitative and was done by wet preparation and formol ethol method (13). About 1g of well-mixed faeces was collected using emulsified stick into a tube containing about 4 ml of 10% formol-water mixture. A little more formol-water was added to the tube and covered with a cap. Tube content was agitated gently for more thorough mixing. The emulsified faecal samples were sieved, and the suspensions collected in a beaker, which was transferred into a centrifuge tube and about 3-6ml of ethyl acetate added. The tube was stoppered and mixed for 1 minute. The stopper was loosened and centrifuged immediately at 3000 rpm for 1 minute. The tube was slightly inverted to discard the ether, faecal debris, and formol-water while leaving the sediment. After mixing the sediment in the tube, it was transferred to a slide and covered with a slip. Specimens were examined under the light microscope using 10x and 40x objective lens, which give a final magnification of 100 and 400 respectively. Three experienced laboratory technologists were employed for the examination and agreement of two of three technologists was accepted in the reading of the slides.

Statistical analysis

Data were analyzed using SPSS version 20.0 software. Descriptive statistics were used and results presented in proportion and tables.

Results:

A total of 829 participants (380 males 46%, 449 females 54%) were recruited for the study. The population-based on age and gender in each community is shown in Table 1. The prevalence of intestinal helminths infection in the four communities is indicated in Table 2 with a total of 218 (26.3%) participants infected and slightly different prevalence rates between the communities. The frequency of identification of helminthes ova in the faecal specimens were; *S. intercalatum* (10.4%), *A. lumbricoides* (6.4%), *S. mansoni* (4.2%), *T. trichiura* (2.6%), hookworm (2.4%) and *Taenia* spp (0.2%) (Tables 2). The prevalence of *S. intercalatum* of 12% and hookworm of 11% were highest in Ibelebiri community. Ova of *Schistosoma mansoni* were found in all the communities with the highest prevalence in Immiringi (11%) and Otuesega (10.5%). The prevalence of tapeworm infection was low (0.5%, n=1) in each of Otuesega and Immiringi (Table 2).

The prevalence of helminthiasis in males is 21.6% (82/380) while the prevalence in the female is 30.3% (136/449) (Table 3). The prevalence of *S. intercalatum* in the females is 13% compared to 7.6% in the males. Similarly, the prevalence of hookworm in females is 5.2%, which is much higher than in males 0.8% (Table 3). All age groups were affected by *Schistosoma* species, although the frequency was highest in the 71-80 years age group (25.0%) infected by *S. intercalatum* and 33.3% in 61-70 years age group infected by *S. mansoni* (Table 4).

Eleven subjects (7 females and 4 males) had double helminth infections representing a prevalence of 1.3% (Table 5), with a combination of *S. intercalatum/A. lumbricoides* (n=6), *S. intercalatum*/hookworm (n=4) and *S. mansoni* /hookworm (n=1) identified in their stool samples. The age group 41-50 years had the highest frequency (n=4). *Schistosoma haematobium* was identified in the stool sample of an eight-year old male (Plate 2).

Table 1: Distribution of the study population for helminthiasis in four rural communities of Bayelsa State, Nigeria, with respect to age group and gender

Parameter	**Gender**		**Total (%)**
	Male (%)	**Female (%)**	
Age group (years)			
<10	168 (50.1)	167 (49.8)	335 (40.4)
10-19	106 (52.7)	95 (47.2)	201 (24.2)
20-29	40 (39.2)	62 (60.7)	102 (12.3)
30-39	25 (30.8)	56 (69.1)	81 (9.7)
40-49	22 (33.8)	43 (66.1)	65 (7.8)
50-59	10 (38.4)	16 (61.5)	26 (3.1)
60-69	6 (40.0)	9 (60.0)	15 (2.0)
≥70	3 (75.0)	1 (25.0)	4 (0.4)
Community			
Otuegela	86 (40.9)	124 (59.1)	210 (25.3)
Ibelebiri	82 (39.0)	128 (61.0)	210 (25.3)
Otuesega	114 (54.5)	95 (45.5)	209 (25.2)
Immiringi	98 (49.0)	102 (51.0)	200 (24.2)
Total	380 (45.8)	449 (54.2)	829 (100)

Table 2: Prevalence of helminthiasis in the study populations in four rural communities of Bayelsa State, Nigeria

Community	**No examined**	**No positive (%)**	***S. intercalatum* n (%)**	***A. lumbricoides* n (%)**	***S. mansoni* n (%)**	***T. trichiura* n (%)**	***Taenia* sp n (%)**	**Hookworm n (%)**
Otuegala	210	45 (21.4)	17 (8.1)	5 (2.4)	16 (7.6)	6 (2.8)	-	1 (0.5)
Ibelebiri	210	59 (28.1)	25 (12.0)	12 (5.7)	8 (4.0)	2 (1.0)	1 (0.5)	11 (5.2)
Otuesega	209	60 (28.7)	22 (10.5)	16 (7.6)	8 (3.8)	8 (3.8)	1 (0.5)	5 (2.4)
Immiringi	200	54 (27.0)	22 (11.0)	20 (10.0)	3 (1.5)	6 (3.0)	-	3 (1.5)
Total	829	218 (26.3)	86 (10.4)	53 (6.4)	35 (4.2)	22 (2.6)	2 (0.24)	20 (2.4)

S = Schistosoma, A = Ascaris, T = Trichuris

Table 3: Prevalence of helminthiasis in the study population with respect to gender in rural communities of Bayelsa State, Nigeria

Gender	**No Examined**	**No positive (%)**	***S. intercalatum* n (%)**	***A. lumbricoides* n (%)**	***S. mansoni* n (%)**	***T. trichiura* n (%)**	***Taenia* sp n (%)**	**Hookworm n (%)**
Male	380	82 (21.6)	29 (7.6)	25 (2.4)	12 (3.2)	9 (2.3)	2 (0.5)	3 (0.8)
Female	449	136 (30.3)	57 (13.0)	28 (5.7)	23 (5.1)	13 (2.9)	-	17 (5.2)
Total	829	218 (26.3)	86 (10.4)	53 (6.4)	35 (4.2)	22 (2.6)	2 (0.24)	20 (2.4)

S = Schistosoma, A = Ascaris, T = Trichuris

Table 4: Prevalence of helminthiasis with respect to age groups among the study population in four rural communities of Bayelsa State, Nigeria

Age group (years)	**No examined**	**No positive (%)**	***S. intercalatum* n (%)**	***A. lumbricoides* n (%)**	***S. mansoni* n (%)**	***T. trichiura* n (%)**	***Taenia* sp n (%)**	**Hookworm n (%)**
1-10	335	100 (29.8)	36 (10.7)	29 (8.6)	20 (6.0)	12 (3.6)	-	3 (0.9)
11-20	201	34 (16.9)	17 (8.4)	5 (2.5)	4 (2.0)	5 (2.5)	-	3 (1.5)
21-30	102	24 (23.5)	8 (7.8)	8 (7.8)	1 (0.9)	1 (0.9)	-	6 (5.9)
31-40	81	23 (28.4)	7 (8.6)	7 (8.6)	3 (3.7)	2 (2.5)	1 (1.2)	3 (3.7)
41-50	65	20(30.7)	10 (15.3)	4 (6.1)	1 (1.5)	1 (1.5)	1 (1.5)	3 (4.6)
51-60	26	4 (15.4)	4 (15.4)	-	-	-	-	-
61-70	15	11 (73.0)	3 (20.0)	-	5 (33.3)	1 (6.7)	-	2 (13.3)
71-80	4	2 (50.0)	1 (25.0)	-	1 (25.0)	-	-	-
Total	829	218 (26.3)	86 (10.4)	53 (6.4)	35 (4.2)	22 (2.6)	2 (0.4)	20 (2.4)

S = Schistosoma, A = Ascaris, T = Trichuris

Table 5: Prevalence of mixed helminthic infection among the study population with respect to age group and gender in four rural communities of Bayelsa State, Nigeria

Parameters/infection	No infected with *S. intercalatum* and Hookworm (%)	No infected with *S. intercalatum* and *A. lumbricoides* (%)	No infected with *S. mansoni* and Hookworm (%)	Total
Age group (years)				
1-10	-	-	-	-
11-20	1	-	1	2
21-30	-	2	-	2
31-40	-	1	-	1
41-50	2	2	-	4
51-60	-	-	-	-
61-70	-	1	-	1
71-80	1	-	-	1
Gender				
Male	1	2	1	4
Female	3	4	0	7
Total	4	6	1	11

S = Schistosoma, A = Ascaris, T = Trichuris

Fig 2: Ova of helminthes identified from stool samples of subjects from Ibelebiri community of Ogbia LGA, Bayelsa State, Nigeria

Discussion:

Identified in this study were ova of six species of intestinal helminths; *S. intercalatum*, *S. mansoni*, *A. lumbricoides*, *T. trichiura*, *Taenia* spp, hookworm, and *S. haematobium* in stool samples. This distribution differs from the commonly reported triad of intestinal helminths, involving *A. lumbricoides*, hookworm, and *T. trichiura* (14). The species of helminths identified is known to vary depending on environmental factors such as temperature, rainfall, humidity, soil moisture, and others such as personal hygiene and level of contamination of the environment (15). In the south-west, the commonest species of helminths reported were *A. lumbricoides* and *T. trichiura* while hookworm and *Strongyloides stercoralis* were the highest prevalence in north-east and north-central regions. A study among primary school children in Aniocha, south-south Nigeria reported three helminths species; *A. lumbricoides*, *T. trichiura* and hookworm (16). In a study of school-age children in Kwara State, four species of intestinal helminths; *Hymenolepis* species, *S. mansoni*, and *Enterobius vermicularis* were identified in stool samples (17). However, across Nigeria, the highly prevalent species of helminths reported are; *A. lumbricoides*, *S. stercoralis*, *T. trichiura* and hookworms (15).

The occurrence of all species of helminths followed a similar trend of declining prevalence with increasing age but the highest prevalence of 73% (11/15) reported in the 61-70 years age group in our study, is contrary to other studies where higher prevalence are reported in younger children as a result of poor personal hygiene practices such as eating with unwashed hands, and spending more time playing out-door without adult supervision (11). As the school age children (< 18 years) were dewormed about 5 weeks before our study, this could account for the much lower prevalence of 29.8% (100/335) in children under 10 years of age. However, the generally low prevalence of helminths infection in adults could be attributed to the relative consciousness of good hygiene practice and less contact with the dirty environment (10).

The prevalence of 6.4% for *A. lumbricoides* reported in our study is lower than 15.0% reported by a study in Edo (18) and 13.1% by another study in Osun State (19). Hookworm infection rate was also low (prevalence of 2.4%) and affected more adults, which could have been acquired by children that walk barefooted, with hookworm larvae actively penetrating the exposed skin. Although, the presence of adequate moisture and optimal temperature allows for larval activity and migration (20), heavy rainfall characteristic of the study settings may have carried infective larvae away into a runoff, which could explain the low infectivity of hookworm in the study areas. The prevalence of taeniasis was 0.2% affecting only adult population in the study. Tapeworm infection is usually associated with consumption of poorly cooked beef or pork meat. However, with the availability of fresh-fish and snails and the peasantry life of the people, consumption of roasted "*suya*" meat or pork is reduced, and this may account for the low prevalence of taeniasis in the study areas.

Most studies have reported *A. lumbricoides* as the most prevalent intestinal helminths in the world (15). This contrasts our finding in this study where the helminthes with the highest prevalence was *S. intercalatum* (10.4%), followed by *A. lumbricoides* (6.4%) and *S. mansoni* (4.2%). Three species of *Schistosoma* were identified; *S. intercalatum*, *S. mansoni* and *S. haematobium* in that order. Ekpo et al., (21) identified all three species of *Schistosoma* in Rivers State, a neighboring State to the study area. Intestinal schistosomiasis was identified in all age groups, reflecting the exposure of the study participants in snail-infested water bodies in the environment. *Schistosoma haematobium* was identified in a stool sample of an eight-year old male. The aberrant presence of species of *Schistosoma* is not uncommon. In a study of urinary and intestinal schistosomiasis among 1,709 children (5-15 years of age) in Port Harcourt, Nigeria (22), ova of *S. intercalatum* were identified in urine samples only, although with a low prevalence of 5.7%, and neither ova of *S. mansoni* nor *S. haematobium* were identified both in stool and urine samples. Eggs of *Schistosoma* or parasite migration can be lodged in strange sites such the central nervous system with may cause compressing of the site with clinical manifestations of pyrexia, headache, vomiting, blurred vision, and Jacksonian epilepsy (23). In Nigeria, the geographical distribution of *Schistosoma* infections depends on availability of the right intermediate hosts (fresh water snails), with *S. mansoni* requiring freshwater *Biomphalaria* snail while *S. haematobium* requires *Bulinus* snail as vectors for transmission (24). Multiple infections in this study involved most commonly *A. lumbricoides* and *S. intercalatum*, followed by *S. intercalatum* and hookworm.

Contact with infective ova of helminths depends on hygiene-behavioral disposition of the population such as hand washing, nail hygiene, and foot-wear practices (25). In the study area, parents, who were mostly peasant farmers, are believed to spend less time caring for their children at home. The children are hence not supervised on hygiene practices such as hand washing after defecation, and this could promote acquisition of helminthic infection. Also, children who were not properly supervised by parents/guardians spent more time recreating in snail-infested water bodies (as shown in Plate 1). Our observation of Kolo Creek showed that it was shallow and slow-flowing, invariably stagnant with dense vegetation, which favors the breeding of snail intermediate hosts (as shown in Plate 3) and the proliferation of miracidium. Although the sanitary condition of the study area was typical of a rural community in a developing country, it is most probable that human activities in snail-infested water bodies are responsible for sustained infection with intestinal platyhelminthes, despite ongoing chemoprophylaxis. This is in agreement with a previous study (26) which showed that persistent transmission of schistosomiasis had cultural affiliation with the use of river water for "drinking" and swimming, implying that behavioral changes are needed to reduce the transmission of schistosomiasis.

The primary objective of any control program is to reduce morbidity (5). Our study observed a lopsided control strategy, where chemoprophylaxis with praziquantel was the only measure adopted by the health intervention program. Praziquantel has been reported to be effective for adult *Schistosoma* parasites only (26), hence combination of some anti-malarial agents such as the artemisinin derivatives (such as artemether) with demonstrated clinical potency in eliminating young stage *Schistosoma* infection (26), may be a better chemoprophylactic strategy.

Conclusion:

The epidemiological implication of combined infection of *Schistosoma* and hookworm in human health is significant in this study. The combination of praziquantel and artemether as chemoprophylaxis for prevention and control of schistosomiasis in the study area should be considered. Additionally, a school-based intervention program should be established to create a platform for screening and treatment of infected pupils. Provision of portable water along with integration of snail control in the Kolo Creek and the surrounding water bodies are highly recommended.

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