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Original Article

Intestinal parasitic infections: Current status and associated risk factors among school aged children in an archetypal African urban slum in Nigeria

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Abstract *Background/purpose:* Intestinal parasitic infections (IPIs) among school aged children (SAC) in Nigeria remains endemic, hence the need for regular surveillance to attract the attention of policy makers. This cross-sectional study investigated the current prevalence and factors associated with intestinal parasitic infections among school aged children in an urban slum of Lagos City, Nigeria.
Methods: Single stool samples from 384 school aged children (188 boys and 196 girls) were examined by employing Merthiolate-iodine-formaldehyde concentration (MIFC) and

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Slum;
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Kato-Katz methods. Demographic characteristics and risk factors were obtained by questionnaires investigation.
Results: The overall prevalence was 86.2% in school children, out of them 39.1% had polyparasitism. IPIs showed the highest to the lowest prevalence of 62% (238/384), 25% (97/384), 12.3% (47/384), 11.8% (45/384), 9.9% (38/384), 8.4% (32/384), 3.4% (13/384), and 0.5% (2/384) found in *Ascaris lumbricoides*, *Entamoeba histolytica/dispar*, *Giardia duodenalis*, *Endolimax nana*, *Entamoeba coli*, *Trichuris trichiura*, *Blastocystis hominis*, and hookworm infections, respectively. MIFC technique showed superiority to Kato-Katz technique in the detection of IPIs ($p < 0.0001$). Drinking untreated water was a significant risk factor for these school aged children in acquiring protozoan infections after multivariate adjustment (OR = 1.86, 95% CI = 1.08—3.20, $p = 0.02$).
Conclusion: Intestinal parasitic infections are very severe among school aged children in the urban slums, thus regular mass de-worming programs, health education, and the provision of safe drinking water is recommended to combat IPIs among the school aged children.

Introduction

Globally, intestinal parasitic infections (IPIs), including helminths and protozoa, remain endemic. About one-third of the world's populations, more than 2 billion people, are infected with the largest majority being children.[1,2] Helminths parasites are mostly *Ascaris lumbricoides, Trichuris trichiura* and hookworms, and are commonly referred to as soil-transmitted helminths (STHs).

A. lumbricoides is the largest and most common helminth, infecting about 819 million people globally, this is followed by *T. trichiura,* which infects about 464.6 million, and hookworm infecting about 438.9 million people globally.[3] Giardiasis and amebiasis, caused by *Giardia duodenalis* and the pathogenic *Entamoeba* spp., respectively, are the two most prevalent protozoan infections, infecting about 200 million and 500 million people, respectively.[4] Another common intestinal protozoan is *Blastocystis hominis*, although its parasitic status is still under debate.[5] Opportunistic IPIs such as *Cryptosporidium, Isospora belli, Microsporidia*, and *Strongyloides* are commonly found in immunocompromised individuals.

A recent report implicating STHs in over thirty-nine million disability adjusted life years (DALYs), and increased mortality rate, highlights the burden of these diseases.[6]

Pre-school and school age children as well as pregnant women are at greatest risk of IPIs-related morbidity.[7] Although IPIs rarely cause death directly, they are associated with poor growth in children, vitamin deficiencies, iron-deficiency anemia, and poor educational performance.[8] Recent studies indicate that poly-parasitized children experience worse cognitive outcomes than those with one parasite, and polyparasitism has been associated with higher mortality rates, as well as enhance susceptibility to other infections.[9]

IPIs are some of the most common human infections in tropical and subtropical countries. In Nigeria, prevalence of IPIs have been reported mostly in the rural parts of the country[10,11] and this has continued due to low living standards, poor sanitation, and ignorance of simple health-promoting behaviors. Poverty has also been linked to these infections.[2] Like many African urban slum community, Makoko, situated in the heart of Lagos city, the biggest town and commercial capital of Nigeria is characterized by substandard housing conditions, poor sanitation and lack of safe drinking water. Although several school-based studies like Nock[12] and Ugbomoiko[13] have been carried out to estimate the IPIs status among Nigerian children, there is paucity of information about children in urban slums such as Makoko, hence the need for this study. It is worth noting that most studies in Nigeria relied on wet mounts and Kato-Katz techniques with a few using concentration methods.[10,11,] The sensitivity of these methods in detecting protozoans and helminths is however very low, particularly in areas with low infection intensities.[14] Reports from previous studies, Hsieh[15] and Fan[16] demonstrated that Merthiolate-iodine-formaldehyde concentration (MIFC) technique is a better option. Hence the MIFC technique alongside the Kato-Katz technique was used in this study to determine the prevalence and intensity of IPIs among schoolchildren in the Makoko slum settlement of Nigeria.

Materials and methods

The geography of Makoko

This cross-sectional study was carried out between November, 2013 and March, 2014, in Makoko, an urban slum located in the heart of Lagos city, the biggest town and commercial capital of Nigeria. It lies between latitudes 6°28′～6°29′S and longitude 3°12′～3°13′E, and has an estimated population of about 100,000 inhabitants, and is administered by the Mainland local government area (LGA) of Lagos State.[17] The climate in Lagos is tropical, hot and wet. The environment is characterized as coastal with wetlands, sandy barrier islands, beaches, low-lying tidal flats and estuaries. The average temperature in Lagos is

27 °C and the annual average rainfall 1532 mm.[18] The settlement is located partly on land and on the Lagos lagoon. Ethnically, the community is dominated by the Ilajes and Egunsa few Yorubas and Igbos as well as other ethnic groups.[19] Their major occupations were fishing and trading especially for those living on the lagoon. Makoko is plagued with severe environmental and infrastructural deficiencies, including inadequate and dilapidated access roads, schools, healthcare facilities, and housing.[17] This study was conducted on the land portion of the community using the only three government-built primary schools, namely, Adekunle Anglican Church Primary School, Ayetoro African Church Primary School, and Makoko Anglican Church Primary School.

Study population and subject selection

The study population constituted of children attending the three government-built primary schools in the slum. Although the total number of pupils enrolled in the three schools was 2699, only 750 consent forms were issued, of which 442 were signed and subsequently 384 children (188 boys and 196 girls) voluntarily participated in the study. In selecting participants for the study, they were first stratified according to their educational level (classes 4, 5, and 6), then randomly sampled using class rosters as the sampling frame.

Since no pilot study was done, the sample size was determined using the general formula, $n = z^2p\ (1 - p)/d^2$ where, n is the sample size, z (1.96) is the standard deviation at a 95% confidence interval (CI), p is the estimated prevalence (50%), and d is the allowed relative error (0.05).[20] The minimum sample size after calculation was 384 children.

Diagnostics and assessment of risk factors associated with IPIs

The IPIs status of participants and the outcome variable — positive or negative — was determined by examining stool samples. A pre-tested structured questionnaire was issued to gather demographic, socioeconomic and personal hygiene practices information. Height and weight of the selected pupils were also recorded using standard calibrated instruments.

Screw capped containers with wide mouths were given to each participant, with instructions on how much stool to put inside, and it was emphasized that only fresh, early-morning stool was acceptable. The stool samples were preserved in 10% formalin solution, and then transported to the Department of Public Health, Nigerian Institute of Medical Research, Lagos, for examination. Each sample was simultaneously processed using the Kato-Katz and MIFC methods then viewed. The Kato-Katz technique was able to estimate the intensity of STHs infections, but was unable to detect protozoan infections. The MIFC technique, on the other hand, is able to detect both STHs and protozoan infections.[16] Any sample with eggs, cysts, trophozoites, or oocysts detected by any of the two techniques was considered positive. For consistency sake and as a form of quality control, 20% of the slides were randomly selected and read again.[21]

Statistical analysis

Differences in the prevalence of infection based on gender, age groups, parents' level of education and occupation (independent variables), were determined by a Chi-squared (x^2) test. The univariate crude odds ratio (COR) and 95% CI were used to determine associations between the independent variables and risk factors for infection. The adjusted odds ratio (AOR) in the multivariate analysis was used to see the strength of the association of the risk factors with infection. p-Values of ≤ 0.05 were considered statistically significant. The age, height, and weight of the children were used in anthropometric calculations of the age-associated body-mass index (BMI, kg/m^2) according to WHO reference tables.[22] All statistical analyses of data from the questionnaire and parasitological examination were carried out using SAS v.9.3 software (SAS Institute, Cary, NC, USA).

Ethical considerations

The guidelines laid down in the *Declaration of Helsinki* for procedures involving human subjects were strictly adhered to, and approval for this study was granted by the Institutional Review Board (IRB) of the Nigerian Institute of Medical Research (NIMR; project no.: IRB/13/225). Prior to commencement of the study, permission was also obtained from the local educational authority in the Mainland LGA. Approval was also obtained from the head teachers of each selected school and from parents or guardians of the children. Meetings were held to explain the objectives and protocol of the study to teachers and pupils', emphasizing that participation was voluntary and that withdrawal from the study at any point was permitted even without a reason. Signed or thumb-printed consent was obtained from the parents/guardians on behalf of their wards before sample collection began. At the end of the laboratory examination, all infected children were treated with appropriate medications like albendazole for nematodes, Praziquantel for trematodes and cestodes, and Metronidazole for protozoan infections, as prescribed by a physician.[23]

Results

In total, 384 children, aged 7—17, with a mean age of 10.8 years took part in the study. The community, being an urban slum, is poverty-stricken.[17] The educational level of parents/guardians correlated with the level of poverty in the community, with about 59.1% with primary/elementary school education as the highest academic level, while 30.5% had secondary/high school education and only 10.4% had attended tertiary institutions. Most of the parents were unemployed (42.7%) or traders (31%), while professionals and other kinds of employments accounted for 18.2% and 8.1% respectively of the remaining population (Table 1).

Collected samples were screened by the previously mentioned techniques for the presence of IPIs. Our result

Table 1 General characteristics of Makoko school aged children investigated for intestinal parasitic infections in an urban slum community, Lagos city of Nigeria ($n = 384$).

Characteristic	*n* (%)
Age group (years)	
<9	90 (23.4)
10–12	227 (59.1)
>12	67 (17.4)
Gender	
Male	188 (49)
Female	196 (51)
Body-mass index (kg/m^2)	
Normal	337 (87.8)
Underweight	47 (12.2)
Occupational status of parents	
Unemployed	164 (42.7)
Traders	119 (31)
Professionals	70 (18.2)
Others	31 (8.1)
Highest educational level of parents	
Primary	227 (59.1)
High school	117 (30.5)
College	40 (10.4)

showed that *A. lumbricoides* (62%) was the most common intestinal parasite, while low prevalence was recorded for *T. trichiura* (8.3%) and hookworms (0.5%). In addition, the intensity of infection ranged from light to moderate, with no heavy infections (fecal eggs per gram (EPG) $\leq$ 5000 for *A. lumbricoides* (mean $\pm$ S.D = 1016 $\pm$ 2861), <1000 for *T. trichiura*, (mean $\pm$ S.D = 15 $\pm$ 65) and <2000 for hookworm (mean $\pm$ S.D = 3 $\pm$ 53)).[24] Infections with intestinal protozoans, which were only detected by the MIFC method, included *Ent. histolytica/dispar* (25.3%), *Endolimax nana* (11.7%), *G. duodenalis* (12.2%), *B. hominis* (3.4%), and *Ent. coli* (9.9%). Among the schoolchildren, 39.1% had polyparasitism with 46.4% having monoparasitism, while 14.6% were IPIs-free. Polyparasitism was further stratified into those with double parasites, 139 (36.6%), and triple parasites, 11 (2.9%) (Table 2).

Comparative analysis of the two methods used, suggested that the MIFC method was more sensitive to IPIs, compared to the Kato-Katz method (Table 3). The results showed no significant difference in prevalence among the age groups, gender, or parent/guardian level of education or occupation (Table 4). After the multivariate analysis, only the pupils that "drank untreated water" showed significant association with protozoan infections (Table 5).

Table 2 Prevalence and species of intestinal parasites in Makoko school aged children in an urban slum community, Lagos city of Nigeria ($n = 384$).

Parasite species	No. positive	Percent (%)	General intensity/ mean (SD)
			Eggs/g of feces
Ascaris lumbricoides	238	62	≤5000 (1016 $\pm$ 2861) (light-moderate)
Trichuris trichiura	32	8.3	<1000 (15 $\pm$ 65) (light)
Hookworm	2	0.5	<2000 (3 $\pm$ 53) (light)
Entamoeba histolytica/dispar	97	25.3	
Endolimax nana	45	11.7	
Giardia duodenalis	47	12.2	
Entamoeba coli	38	9.9	
Blastocystis hominis	13	3.4	
Infection status			
No parasites	56	14.6	
Monoparasitism	178	46.4	
Polyparasitism	150	39.1	
No. of parasite species in polyparasitism			
Two	139	36.1	
Three	11	2.9	

Table 3 Comparison of the detection efficiency between the Kato-Katz and Merthiolate-iodine-formaldehyde concentration (MIFC) techniques.

Technique ($n = 384$)	Intestinal parasitic infection		Percent (%)	*p* Value
	Positive	Negative		
Kato-Katz	193	191	50.3	<0.0001
MIFC	246	138	64.1	

Discussion

Intestinal parasitic infections (IPIs) remains a worldwide problem with an estimated 400 million school aged children infected. In sub-Saharan Africa, IPIs constitutes a major health concern, with predisposing factors such as poverty, poor sanitation, ignorance, and malnutrition.[25] Many of the studies performed in Nigeria to determine the prevalence of these infections were carried out in the rural areas,[12,26–28] with limited studies in urban slum communities like Makoko.

In our study, the prevalence of IPIs was 86.2%, which is consistent with the 92.7% recorded in southern Ethiopia.[29] In contrast, our estimated prevalence (86.2%) was higher compared to findings from an urban slum in Karachi, Pakistan (52.8%)[30] and that from Nepal (31.5%).[31] In West Africa, a prevalence of 60.8% was reported in Burkina Faso[32] while 55.2% prevalence was recorded in Cote'd'Ivoire.[33] Differences in prevalence might be explained by the timing or seasonal differences of conducted surveys, environmental conditions, or other factors like mass deworming programs in the study areas.

Some other studies have reported higher prevalence of 95.7% and 94% in Nigeria,[27,34] although only for intestinal helminths, while others showed lower prevalence of 50.4% and 50.6% in south-western and south-eastern Nigeria, respectively.[10,35] One other study reported a lower prevalence of 48.4% in an urban community in south-west Nigeria.[36] These differences could be attributed to different predisposing factors in rural communities, where

Table 4 Patterns of intestinal parasitic infections with demographic and socioeconomic factors in Makoko schoolchildren in an urban slum community, Lagos city of Nigeria.

Variable	*n*	Soil-transmitted helminths			Protozoa			Both		
		Positive	Rate	*p* Value	Positive	Rate	*p* Value	Positive	Rate	*p* Value
Age group (years)										
<9	90	54	60	0.6	51	56.67	0.4	26	28.89	0.71
9–12	227	147	64.76		120	52.86		72	31.72	
>12	67	45	67.16		31	46.27		18	26.87	
Gender										
Male	187	127	67.91	0.13	99	52.94	0.9	61	32.62	0.3
Female	195	118	60.51		102	52.31		54	27.69	
Body-mass index										
Normal	337	221	65.58	0.09	183	54.3	0.07	105	31.16	0.28
Underweight	47	25	53.19		19	40.43		11	23.4	
Parent's occupation										
Unemployed	164	104	63.41	0.7	84	51.22	0.93	45	27.44	0.16
Trader	119	74	62.18		63	52.94		34	28.57	
Professional	70	49	70		39	55.71		29	41.43	
Others	31	19	61.29		16	51.61		8	25.81	
Parent's education										
Primary	241	159	65.98	0.6	120	49.79	0.26	72	29.88	0.32
High School	103	63	61.17		57	55.34		28	27.18	
College	40	24	60		25	62.5		16	40	

Table 5 Multivariate logistic analysis of intestinal parasitic infections with risk factors for Makoko schoolchildren in an urban slum community, Lagos city of Nigeria.

Variable	Model I[a]			Model II[b]			Model III[c]		
	AOR	95% CI	*p* Value	AOR	95% CI	*p* Value	AOR	95% CI	*p* Value
Age group (years)									
<9	1.00			1.00			1.00		
9–12	1.03	0.45–2.37	0.94	0.75	0.33–1.72	0.5	0.81	0.34–1.92	0.63
>12	1.68	0.62–4.57	0.31	0.51	0.19–1.32	0.16	0.83	0.31–2.27	0.72
Gender									
Male	1.00			1.00			1.00		
Female	0.77	0.46–1.29	0.32	1.01	0.61–1.66	0.89	0.95	0.55–1.63	0.84
Body-mass index									
Normal	1.00			1.00			1.00		
Underweight	0.63	0.29–1.39	0.25	0.44	0.19–0.98	0.05	0.44	0.16–1.22	0.11
Parent's occupation									
Unemployed	1.00			1.00			1.00		
Professionals	1.33	0.62–2.84	0.47	0.89	0.43–1.83	0.75	1.31	0.61–2.83	0.49
Others	1.50	0.42–5.35	0.53	0.60	0.19–1.93	0.4	0.82	0.23–2.93	0.76
Parent's education									
Primary	1.00			1.00			1.00		
High School	0.92	0.49–1.72	0.8	1.27	0.69–2.32	0.44	0.95	0.49–1.84	0.88
College	0.61	0.27–1.37	0.23	1.71	0.77–3.82	0.19	1.40	0.61–3.24	0.43
Drank untreated water									
No	1.00			1.00			1.00		
Yes	0.84	0.48–1.48	0.55	1.86	1.08–3.20	**0.02**	1.61	0.89–2.92	0.12
Consumed raw vegetables									
No	1.00			1.00			1.00		
Yes	1.28	0.74–2.19	0.38	0.88	0.53–1.48	0.64	1.12	0.65–1.95	0.68

Model I[a]: soil-transmitted helminths; **Model II[b]**: protozoa; **Model III[c]**: both.

most of the studies were done, as well as different detection techniques.

Our findings indicated that over 80% (331/384) of the school aged children tested positive for at least one parasite species, with *A. lumbricoides* being the most prominent parasite (62%). This is consistent with results of previous studies in other parts of Nigeria.[10,11,13] It has been estimated that approximately 15 million Nigerians suffer from *Ascaris* infection alone.[37] The possible reason for the high prevalence of *Ascaris* could be their embryonated eggs that have an enormous capacity to withstand environmental extremes. Furthermore, the eggs are coated with a mucopolysaccharide that renders them adhesive to a variety of surfaces like vegetables, fruits, door handles, and money.[36] Prevalence of *T. trichiura* and hookworm were low, at 8.4% and 0.5%, respectively, similar to the findings of Ekpenyong.[38]

The *Ascaris*-hookworm-*Trichuris* triad pattern of infection that is common in African communities, was also confirmed in our study. The low to moderate STHs infection intensities encountered in our study is suggestive of the chronic nature of the infections in the community.[39] Absence of high intensity cases in this study could probably be attributed to inadvertent exclusion of those with heavy parasite loads due to absence from school sequel to IPIs-associated illness.[40]

Intestinal protozoans were also recorded in this study, with *Ent. histolytica/dispar* having the highest prevalence (25.3%), followed by *G. duodenalis* (12.3%) and *End. nana* (11.8%). Others included *Ent. coli* (9.9%) and *B. hominis* (3.4%). Few studies in Nigeria also reported the prevalence of protozoan parasites, like 7.3% prevalence in *Ent. histolytica*.[41] Unfortunately, pathogenic protozoan infections in school aged children have not received adequate attention from the Nigerian Health Authority. Pathogenic protozoan infections by amoebas, *B. hominis,* and *G. duodenalis*, among others, are known to cause gastrointestinal problems of varying severities and outcomes, including rendering school aged children unable to attend school due to diarrhea or severe abdominal pain, consequently leading to low academic performance.[23,24]

This study had a prevalence of 39.1% of the children with polyparasitism, of which 36.1% had double intestinal parasites while 2.9% had triple parasites. Those with single parasitic infection were 46.4%. This result is suggestive of the highly contaminated nature of the Makoko settlement, as with most African urban slum communities. The highest co-infection was noted for *A. lumbricoides* and *Ent. histolytica/dispar* (14%), which is similar to results from southwest Nigeria.[36] *A. lumbricoides* co-infection with *End. nana* and *G. duodenalis* were 5% and 4%, respectively. This finding is important because polyparasitism may lead to multiple morbidities due to each parasite species. Several studies have shown that infection with STHs and *G. duodenalis* are indicators of vitamin A deficiency, iron-deficiency anemia, malnutrition, poor cognitive function and sub-optimal school performance.[8,23]

The association of age with infection was not significant; all age groups were almost equally exposed. This could be as a result of the general contamination of the environment, even though younger children are generally reported to have higher prevalence due to their poor personal hygiene like geophagia/pica.[7] Boys and girls had similar prevalence, so infection was not gender -dependent in this study, which is consistent with other studies.[17,42] Associations of anthropometric indices with IPIs are contradictory. Some studies reported positive associations[43,44]; while others showed no associations.[45,46] In our study, no association was found between the BMI and infection in the univariate or multivariate logistic regression analyses. The occupation of parents/guardians showed a significant association with infection in the univariate analysis, but this was not retained in the multivariate analysis, indicating no strong association with infection. The group "Professionals" had to be created due to the diversity of occupations encountered in the community which included; builders, welders, and cleaners among others, while the group "Others" referred to occupations which we could not readily categorize. The findings in the study indicate that probably due to the contamination of the environment, all classes of people were equally exposed to infection.

We found that among the risk factors for infection which included playing with soil, drinking untreated water, and consuming raw vegetables, there was only a significant association between drinking unsafe water and infection, which was shown in the multivariate analysis. This agrees with studies previously carried out, though not in slums, in central, southeastern, southwestern, and northern Nigeria.[38,47–49] Although Nigeria is the largest country in sub-Saharan Africa, about three-quarters of its population have no access to safe drinking water.[50] The slums and rural areas are worst affected, and this has great consequence on the health of the entire nation. In rural Malaysia and Nicaragua, it is also reported that unsafe drinking water is a very significant risk factor for IPIs.[23,51]

The location of Makoko right at the heart of the biggest city in the country is of great concern, as movement of people and goods, like fish and vegetables, from such highly contaminated environments to other parts of the city exposes the entire city to the risk of infections by various intestinal parasites.

Based on this study, it is recommended that the government should intensify efforts to provide safe water, and promote locally feasible methods of purifying water, such as boiling.[46] The use of water disinfection products like Aquatabs (sodium dichloroisocyanurate), liquid bleach (sodium hypochlorite), and granular chlorine may also be encouraged, as they have been found to be effective in such local settings.[52]

The Kato-Katz method which was originally developed for diagnosing intestinal schistosomiasis,[53] then later recommended by the WHO for assessing the prevalence and infection intensity of STHs, was found to be lacking in sensitivity, particularly in areas with high proportions of mild-intensity infections.[14,54] Other more sensitive techniques such as polymerase chain reaction and FLOTAC, are cost intensive and require advanced technical skills, and thus are not economical for large-scale epidemiological surveys in resource-poor settings. The MIFC technique, on the other hand, was found to be highly sensitive, being more efficient in detection of various intestinal parasites than other methods.[16] In addition, the MIFC method was also found to be economical for large-scale surveys and requires no special skills. Its procedure is also more

hygienic compared to Kato-Katz.[16] In our study, the difference in prevalence detected by the two techniques was statistically very significant ($p < 0.0001$).

We acknowledge some limitations in the study methodology. We relied on a single stool examination, instead of the standard three samples required on different days. This was due to limited resources and cultural beliefs of the community about giving stool samples. Microscopy was used, which is not a very sensitive tool especially with mild infections and with only a single stool sample, but the sensitivity was increased by using two diagnosis methods. The use of only prevalence in this study may explain why we found no relationship between infection and most risk factors.

In conclusion, the high prevalence of IPIs recorded among school children in this urban slum community requires prompt intervention programs, with emphasis directed at the provision of safe drinking water and education on personal as well as environmental hygiene for both children and parents. This can be done through mass media, teachers, physicians, and other healthcare workers. The government should also develop programs that can alleviate poverty in this community and provide basic amenities. Regular mass de-worming programs are also important. The MIFC technique is also recommended for large-scale surveys and also as a diagnostic tool in hospitals.

Conflict of interest

The authors declare that there is no conflict of interest.

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