Malaria and Soil-Transmitted Helminth Co-Infection Among School-Aged Children in Mkpat Enin Local Government Area, Akwa Ibom State, Nigeria

ABSTRACT

Malaria, caused by *Plasmodium falciparum*, and soil-transmitted helminths (STHs), caused by *Ascaris lumbricoides*, *Trichuris trichiura*, and *Ancylostoma duodenale*, are highly prevalent parasitic infections of public health significance in Nigeria. Coinfection with these parasites of such co-infections is crucial for designing effective public health strategies. This cross-sectional study assessed the prevalence of malaria and soil-transmitted helminth co-infections among primary schoolchildren in Mkpat Enin Local Government Area (LGA), Akwa Ibom State. Between May and July 2024, finger-prick blood and stool samples were randomly collected from 348 children aged 4–15 years across four primary schools. Malaria parasites were identified using thin-film microscopy of air-dried blood smears, while stool samples were analysed for STH ova using the formalin-ether concentration technique. The prevalence of *Plasmodium falciparum*was 21.5%, while the prevalence of *Ascaris lumbricoides*, *Trichuris trichiura*, and *Ancylostoma duodenale* was 9.5%, 5.7%, and 2.6%, respectively. The overall co-infection rate of malaria and STHs was 7.8%, with significant associations between these infections ($p < 0.05$). Malaria prevalence was slightly higher in males (21.8%) compared to females (21.3%), whereas STH infections were more common in females (19.6%) than in males (15.8%), these were not statistically significant ($p > 0.05$). Age-specific prevalence~~,~~showed that children aged 14 years and older had the highest malaria prevalence (29.4%), while those aged 9–13 years had the highest prevalence of STH infections (19.4%). This study highlights the considerable burden of malaria and STH infections among primary school children in Mkpat Enin LGA, with variations in prevalence influenced by age and sex. This ~~ese~~ findings underscore the need target public health interventions that address parasitic infections, considering demographic factors that influence their distribution.

Keywords: Malaria, Soil-transmitted helminths, Co-infection, Prevalence, Akwa Ibom State.

INTRODUCTION

Concomitant parasitic infections occur when two or more parasites coexist within a host, potentially altering ~~the~~ immune response to individual parasites and modifying the clinical outcomes. For instance, helminths can influence malaria severity by either mitigating or exacerbating its clinical manifestations(Ojurongbe *et al*., 2010). Malaria, a febrile disease caused by protozoan parasites of the genus Plasmodium, is transmitted via the bite of infected female Anopheles mosquitoes (Udofia *et al*., 2021~~).~~.

Soil-transmitted helminthiasis (STHs), one of the most prevalent neglected tropical diseases (NTDs) in Nigeria, remains a significant global health challenge, particularly in impoverished and underserved communities where control measures are difficult to implement.

According to the 2023 World Malaria Report, there was approximately 249 million cases of malaria in 2022,~~and~~ a slight increase from 244 million in 2021. Malaria-related deaths were estimated at 608,000 in

2022, compared to 610,000 in the previous year [7]. Globally, approximately 1.7 billion people are infected with one or more STHs. A 2003 survey estimated that over 1.2 billion individuals were infected with *Ascaris lumbricoides*, with more than half of these cases occurring in China. Additionally, the prevalence of *Trichuris trichiura*was estimated at 795 million, and hookworm infections affect ed approximately 740 million people [8, 9]. Despite increasing interest in understanding the dynamics of malaria-helminth co-infections, particularly their prevalence, clinical implications, and risk factors, longitudinal, community-based studies remain scarce. This is especially true in rural areas, such as Mkpat Enin Local Government Area, Akwa Ibom State, Nigeria. This study aimed to address this gap by exploring the prevalence and interactions of malaria and helminth co-infections in this region [2, 10].

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in four primary schools in the Mkpat Enin Local Government Area, Akwa Ibom State. Mkpat Enin is located at longitude 8° 30' and latitude 5° 30' in the Southern region of Nigeria,it covering an area of 42km^2 (Fig.1). The population primarily consists of civil servants and farmers.

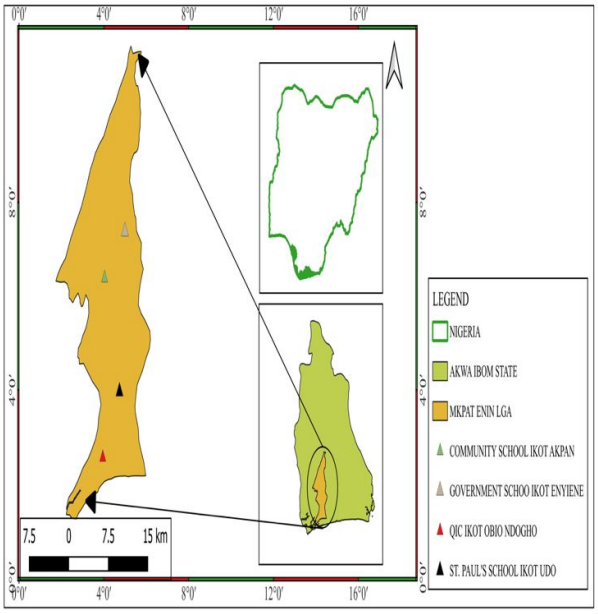

Figure 1 : Map of Mkpat Enin Local Government Area, showing the study location.

2.2: Study Design

This study was a cross-sectional, school-based investigation involving 348 pupils recruited over three months using a multistage sampling technique. The sample size was proportionately distributed across the four selected schools, considering the total pupil population in each school. Participants were selected through simple paper balloting, where students picked slips marked "YES" or "NO"; those who picked

"YES" were included in the study. A total of 348 stool and blood samples were collected from pupils in~~of~~ the four schools, with 87 stool samples collected from each school. The schools randomly selected for the study included: Community School, Ikot Akpan, ~~and~~ St. Paul's School, Ikot Udo, Government School, Ikot Eyiene, and QIC School, Ikot Obio Ndoho.

2.3: Study population and Sample size estimation

The study population consisted of children aged 4 -15 years who provided assent and whose parents or guidians gave written informed consent.

The sample size was determined using the formula:

$n = z2pq / d^2$

where n=required sample size,

Z=confidence interval at 95% (standard value=1.96),

P = estimated prevalence (24%, i.e., 0.24),

q (1−p)= expected non-prevalence,

d=margin of error at 5% (0.05)

Based on this formula, the minimum calculated sample size was 343 participants. To account for non-response, 348 participants were recruited~~.~~

2.4 Collection of Blood Samples and Microscopic Examination

Blood samples were collected using sterile conditions by a trained laboratory technician. After cleaning the middle or ring finger with a 70% alcohol-moistened swab, the finger was dried with clean cotton and pricked with a sterile lancet. Blood smears were prepared as follows: Thin blood film: A small drop of blood was placed at one end of a clean slide and spread using another slide held at an angle to create a thin film~~,~~ Thick film: Three drops of blood were placed on~~at~~ the opposite end of the slide and spread evenly with an applicator.

Slides were air-dried and transported to the laboratory in a slide box. Fixation was performed with methanol, and the slides were stained with 10% Giemsa solution for 10 minutes. After staining slideswere rinsed with distilled water, air-dried, and examined under a microscope using a x100 oil immersion lens.

2.5 Collection and Examination of Stool Samples

Stool samples were collected in clean, leak-proof, sterile containers~~,~~ and preserved in 10% formalin. The samples were processed using the formalin-ether concentration technique.as follows:Two millilitres of preserved stool were added to a clean conicalcentrifuge tube containing 7 mL of 10% formalin water. The mixture was filtered through a sieve into a 15 mL conical centrifuge tube. Four millilitres of diethyl ether were added to the filterate, and the tube wascentrifuged at 300rpm for 1 minute.The supernatant was discarded, and smears were prepared from the sediment onto sterile slides.~~with~~ Three slides were prepared for each participant and examined microscopically by two independent experts using 10x and

40x objective lenses to identifyhelminth ova and cysts.

2.6 Data Analysis

~~The~~ Collected data were stored in Microsoft Excel and validated before the analysis. Statistical analyses were performed using IBM SPSS version 21 (IBM SPSS Inc., Chicago, IL, USA). Descriptive statistics, including frequencies and percentages, were used to summarize variables. Chi-square tests were applied to assess ~~the~~ associations between malaria and helminth co-infections and related risk factors.~~,~~ Pearson's correlation test was employed to evaluate the strength of associations between variables. Statistical significance was set at $p < 0.05$.

3.0 RESULTS

A total of 348 stool and ~~348~~ blood samples were collected from pupils in four primary schools,comprising 184female(52.6%) and 165 males(47.4%). The sociodemographic characteristics of the participants are summarized in Table 1. The prevalence of *Plasmodium falciparum*was75(21.6%, *P*=.01).Three species of soil-transmitted helminths (STHs) were detected:~~in the study:~~*Ascaris lumbricoides*, (33, 9.5%),*TrichurisTrichiura* (20, 6.0%), and *Ancylostoma duodenale*, (9, 2.6%), resulting in a total STH prevalence of 62(17.8%, p = .00). The prevalence of malaria and helminth infections varied schools (Table 3). St Paul School, Iket Udo had the highest malaria prevalence at 25 (28.7%) and the highest coinfection rate(9.2%), while~~(~~Government School, Ikot Eyenene~~),~~~~had~~ recorded the highest STH prevalence at 21 (24.1%).

As shown in Table 4, coinfections of*Ascaris* and *Plasmodium*were the most common, with a prevalence of 14(4.0%). Children aged 4-9years had the highest coinfection rates of *Ascaris* and *Plasmodium*(6, 4.7%), while children aged 10-15years had the highest rates of *Trichuris* and *Plasmodium*coinfection (5, 2.3%). Malaria was slightly more prevalent among males (36, 21.8%) than females (39, 21.3%), with no significant sex difference (p = 0.92). Conversely, STH infections were more prevalent in females (36, 19.6%) than males (26, 15.8%), though the difference was not statistically (p = 0.54) (Table 5).

Figure 1 illustrates therate of coinfection by sex. Females exhibited a higher prevalence of *Plasmodium*, *Trichuris* and *Ascaris* coinfection (4, 2.2%), compared to males, who had the highest prevalence of *Trichuris* and *Plasmodium* coinfection (4, 2.4%).

Table1: Showing the socio-demographic variables of primary school children sampled for the study

Parameters		No. Examined
Sex	Female	183 (52.6%)
	Male	165 (47.4%)
Age	4-9	129 (37.1%)
	10-15	219 (62.3%)
Schools	COMMUNITY SCHOOL IKOT AKPAN	87 (25.0%)
	ST PAUL'S SCHOOL IKOT UDO	87 (25.0%)
	GOVERNMENT SCHOOL, IKOT EYIENE	87 (25.0%)
	QIC IKOT OBIO NDOHO	87 (25.0%)

Table 2: Prevalence of malaria parasites and soil-transmitted helminths

Parasite	Number examined	*Plasmodium falciparum*	*Ascaris lumbricoides*	*Trichuris trichiura*	*Ancylostoma duodenale*	Total Helminths
Positive	348	75	33	20	9	62
Negative	348	273	268	327	339	286
Total	348	75 (21.6%)	33(9.5%)	20(6.0%)	9(2.6%)	62(17.8%)
P value		0.01*	0.003*	0.004*	0.0001*	0.002*

Table 3: Prevalence of soil-transmitted helminths among pupils according to school

Name of school	Total number examined	Total number infected with Malaria	Total number infected with any STHs	Mixed Infection (Malaria & Helminth)
Community school Ikot Akpan	87	19 (21.8%)	14 (16.1%)	5 (5.7%)
St Paul's School, Ikot Udo	87	25 (28.7%)	11 (12.6%)	8 (9.2%)
Government School Ikot Eyennene	87	18 (20.7%)	21 (24.1%)	7 (8.0%)
QIC Ikot Obio Ndoho	87	13 (14.9%)	16 (18.4%)	5 (5.7%)

Table 4: Showing the prevalence of co-infection by age

Age	No. examined	Ascaris + Plasmodium	Ascaris + Trichuris + Plasmodium	Trichuris + Plasmodium	Ancylostoma + Ascaris
4-9	129	6 (4.7%)	2 (1.6%)	1 (0.8%)	0
10-15	129	8 (3.7%)	3 (1.4%)	5 (2.3%)	2 (0.9%)
Total	348	14 (4.02%)	5 (1.4%)	6 (1.7%)	2 (0.6%)
P-value		0.74	0.75	0.74	0.75

Table 5 : Showing the prevalence of parasites by sex and age

Sex	No. examined	*Plasmodium*	*Ascaris lumbricoides*	*Trichuris trichiura*	*Ancylostoma duodenale*
Female	183	39 (21.3%)	19 (10.4%)	11 (6.0%)	6 (3.3%)
Male	165	36 (21.8%)	14 (8.5%)	9 (5.5%)	3 (1.8%)
Total	348	75 (21.6%)	33 (9.5%)	20 (5.7%)	9 (2.6%)
P-value		0.92	0.53	0.82	0.38
Age					
4-9	129	26 (20.2%)	15 (11.69%)	11 (8.5%)	3 (2.3%)
10-15	219	49 (22.4%)	18 (8.2%)	9 (4.16%)	6 (12.7%)
P-value		0.63	0.73	0.75	0.74

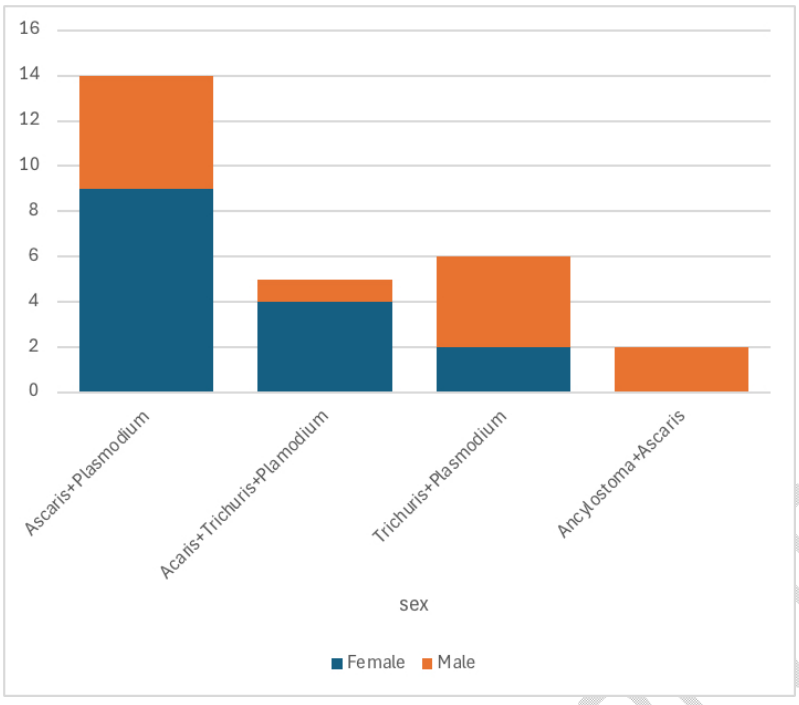

Figure 2: A graph showing the rate of coinfection by sex

4.0 Discussionnot 5

Children in endemic regions, such as Nigeria, frequently~~often~~ experience co-infections with malaria and soil-transmitted helminths (STHs), driven by environmental and climatic conditions condusive to the transmission of both infections [13].In this study, the coinfection rate for malaria and STH was 7.8%. This rate is higher than the 5.9% reported by [14] in Osogbo, Nigeria, but lower than the 9.49% reported by [9]. A significant association between malaria and STH co-infection was observed in this study (p =.05).

The prevalence of malaria parasites was 21.5%, lower than the 27.3% reported by [15] in Ajagba, Southwestern Nigeria, but higher than the 11.1% prevalence reported by [16]in Ethiopia by Author et al.(year). No significant variation was found between males (21.8%) and females (21.3%) (p =0.92), consistent with previous studies [17-18]. Thesefinding indicates that both sexes are equally exposed to malaria factors, suggesting that sex is not a determinant of malaria susceptibility [19]. Children aged > 10 years had the highest prevalence of malaria (22.4%), which aligns with studies linking older children to increased outdoor activities that heighten exposure to mosquito vectors (Ref)

Soil-transmitted helminthiasis caused by *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms was also documented in this study, consistent with findings from previous researchers [5,20,21]. The overall prevalence of STH infections ~~was~~(17.8%) was lower than the 45.3% reported by [22] in Itu Local Government, Akwa Ibom State, but slightly higher than the 17.44% reported in Akwa

North LGA, Anambra State [9]. Additionally, the prevalence was lower than the 24.2% observed in Eastern Obolo, Akwa Ibom State [13]. The relatively low prevalence of parasitic infections in this study may be attributed to improved sanitation, mass distribution of insecticide-treated mosquito nets, routine use of anti-helminthic drugs, and government-led mass-deworming campaigns. Among the detected helminths, *Ascaris lumbricoides* was likely related to poor water supply and inadequate sanitation facilities, which facilitates its transmission. Children aged 4–9 years had the highest prevalence of STH infections (22.5%), consistent with studies indicating that younger children are more likely to play in contaminated environments and have poor hygiene practices, increasing their susceptibility (Ref). Females demonstrated a higher prevalence of STH infections (19.6%) compared to males (15.8%). This aligns with the higher prevalence rates reported among females (51.9%) compared to males (45.3%) in Ethiopia [23]. The observed differences could be influenced by behavioural, biological, or social factors, although the differences in this study was not statistically significant (p =0 .73)

5.0 Conclusion

This study highlights the significant prevalence of malaria and STH infections among primary school children in Mkpat Enin Local Government Area. While Infection rates varied by age, no significant differences were observed between sexes. The predominant parasites identified were *Plasmodium falciparum*, *Ascaris lumbricoides*, *Trichuris trichiura*, and *Ancylostoma duodenale*. A coinfection rate of 7.8% was recorded among the 348 pupils examined, with*A. lumbricoides* (9.5%) being ~~was~~ the most prevalent helminth and*P. falciparum* (21.6%) the most common malaria parasite.

Consent

In accordance with ~~As per~~ international ~~or~~and university standards, ~~respondents'~~ written consent was obtained from all respondents and securely ~~collected and~~ preserved by the author(s).

Ethical consideration

Ethical clearance and approval (HREC, No. AKHREC/30/05/24/218) were obtained from the Department of Research and Education Ethical Committee of the State Ministry of Health~~,~~ to conduct the study involving the collection of specimens from primary school pupils in Mkpat Enin LGA. Prior to sample collection, written informed consent was obtained from the parents or guardians of the pupils~~. before samples were collected.~~

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