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Polyparasitism with malaria and intestinal parasite infections in febrile children attending General Hospital Bayara, Bauchi State, Nigeria

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ABSTRACT

This study aimed to detect the prevalence of polyparasitism with malaria and intestinal parasite infections in febrile children aged 1-10 years attending General Hospital Bayara in Bauchi state. A cross-sectional study was conducted between February and October 2023, involving the collection of fresh stool and blood samples from febrile children admitted to the hospital. The blood samples were subjected to thin and thick blood film examinations using Giemsa stain to detect malaria parasites. At the same time, the wet mount smear and zinc flotation methods were employed to detect intestinal parasites. Statistical analyses were performed, including Pearson's chi-square and multivariate analysis (MANOVA). The study included 666 children, with an overall prevalence of malaria and polyparasitism observed at 76.3%. *Plasmodium falciparum* was the most common malaria parasite, infecting 57.3% of the children. The intestinal parasites detected included *Ancylostoma duodenale* (22.4%), *Ascaris lumbricoides* (15.6%), *Entamoeba histolytica* (3.3%), *Giardia lamblia* (1.0%), and *Taenia species* (0.4%). A significant association was found between malaria and the irregular use of long-lasting insecticidal nets (LLIN) ($p = 0.002$). However, no significant association was observed between polyparasitism and communities of children infected with malaria ($p = 0.340$). The study concludes that malaria and intestinal parasite infections remain major public health problems in the study area, highlighting the need for effective control measures to reduce the prevalence of these infections.

ABSTRAK

Penelitian ini bertujuan untuk mendeteksi prevalensi poliparasitisme dengan malaria dan infeksi parasit usus pada anak-anak demam berusia 1-10 tahun yang berkunjung ke Rumah Sakit Umum Bayara di negara bagian Bauchi. Sebuah studi potong lintang dilakukan antara Februari dan Oktober 2023, yang melibatkan pengumpulan sampel tinja segar dan darah dari anak-anak demam yang dirawat di rumah sakit. Sampel darah diperiksa dengan metode apusan darah tipis dan tebal menggunakan pewarnaan Giemsa untuk mendeteksi parasit malaria. Sementara itu, metode apusan basah dan flotasi seng digunakan untuk mendeteksi parasit usus. Analisis statistik dilakukan, termasuk chi-kuadrat Pearson dan analisis multivariat (MANOVA). Studi ini melibatkan 666 anak-anak, dengan prevalensi keseluruhan malaria dan poliparasitisme sebesar 76,3%. *Plasmodium falciparum* adalah parasit malaria yang paling umum, menginfeksi 57,3% dari anak-anak. Parasit usus yang terdeteksi meliputi *Ancylostoma duodenale* (22,4%), *Ascaris lumbricoides* (15,6%), *Entamoeba histolytica* (3,3%), *Giardia lamblia* (1,0%), dan *Taenia species* (0,4%). Ditemukan asosiasi yang signifikan antara malaria dan penggunaan tidak teratur jaring insektisida tahan lama (LLIN) ($p = 0,002$). Namun, tidak ada asosiasi signifikan yang diamati antara poliparasitisme dan komunitas anak-anak yang terinfeksi malaria ($p = 0,340$). Penelitian ini menyimpulkan bahwa malaria dan infeksi parasit usus tetap menjadi masalah kesehatan masyarakat yang besar di daerah studi, menyoroti kebutuhan akan langkah-langkah pengendalian yang efektif untuk mengurangi prevalensi infeksi ini.

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1. Introduction

Parasites inhabit all places across various world regions [1]. Infection with more than one parasite, dubbed as polyparasitism, is an issue that is on the rise among disparate communities of tropics and subtropical regions of the world [2]. A typical public health issue affecting various Sub-saharan areas of Africa is the prevalence of polyparasitism, including a confection with malaria and many other parasites affecting the human intestine and relations. Endemic disease areas ideally support the widespread presence of various parasites due to overlapping patterns. For instance, malaria and intestinal parasites are influenced by similarity in transmission means, epidemiological dispersion interactions, and immune modification [1, 3-4].

In Sub-saharan areas, a large chunk of the population, including children, adults, infants, and females, are at risk of polyparasitism due to the presence of various disease determinants unperturbed [4-7]. Polyparasitism distinctively causes many effects, such as derangement in development, malnutrition, poor mental development, and poor physical health [8-9]. Moreover, intestinal infections are prevalent in leading to effects such as abdominal pain, diarrhea, ulcers, cognitive deficit, and even death [10-11]. Worrisomely, malaria infection in endemic places spurs a condition that is characterized by life-threatening effects. This condition reveals low levels of symptoms or becomes asymptomatic; therefore, it is primarily untreated. In turn, the children (or anyone included) suffer from anemia due to disrupted iron metabolism [12-13]. In the Sub-saharan African region, many children leave schools for hospitals due to malaria con, consequently leading to poor educational achievement [12]. In a situation whereby about half of the Nigerian population are children below the age of 14, and this proportion of children lives in rural settings characterized by poor healthcare, it is pertinent to research various groups of vulnerable children [1, 14-15]. Regular studies on polyparasitism will help estimate how far the prevention and control interventions have gone; it will also give policymakers an arena of improvement arousal [11]. Relatedly, information is made available for further scrutiny and study to improve public health using scientifically supported information like the one presented in this work [11].

Generally, malaria appears to increase the incidence of intestinal parasite infections in adults. However, more research is needed to evaluate this effect in children [16]. Most research on parasitic disease-related morbidity associated with malaria focused on single species of intestinal parasite infections, whilst the health impact due to polyparasitism remains poorly understood [17]. For a country like Nigeria, where polyparasitism is still widespread [18], a deeper mechanistic understanding of multiple species of parasite infections is crucial for disease control and reducing the burden due to these intestinal parasitic infections.

The most significant knowledge gap is in children, who are the population at the highest risk for severe malaria and intestinal parasite infections. There are approximately 181 million cases of malaria co-infection with intestinal parasite infections among children living in sub-Saharan Africa. However, little is known about the effects of malaria severity and intestinal parasitic infections. Most studies on the parasite infections with malaria were done in developed countries and mainly included adults. The prevalence of malaria and intestinal parasites among children has not been very well understood in resource-poor settings like Nigeria. However, few cross-sectional studies are conducted in different parts of the country. However, knowing malaria parasitaemia and intestinal parasite infections among children through case-control studies will help screen and manage infected children according to their causes. Furthermore, data are scarce regarding polyparasitism with malaria and intestinal parasite infections in febrile Children aged between 1 and 10 years. Therefore, this study aimed to determine the prevalence of polyparasitism with malaria and intestinal parasite infections in febrile Children attending General Hospital Bayara, Bauchi State.

2. Methods

2.1. Study Area and Population

General Hospital Bayara is located at Birshi with a latitude of 10°12’38” N and a longitude of 9°43’36” E along Langtang-Federal Road within the capital city of Bauchi State. Bayara is situated approximately 10.3 km away from the Bauchi metropolis. Bauchi is located on the northern edge of the Jos Plateau at an elevation of 616 meters. The Bauchi local government covers an area of 3,687 km² and had a population of 493,810 in 2006 [19], of which 287,234 were children aged between 1 and 10 years. The leading ethnic group is Hausa, and the Hausa language is predominantly used for communication. Most of the inhabitants are engaged in small-scale farming, with only a few working as civil servants.

2.2. Ethical Approval

Ethical approval was obtained from the Bauchi State Ministry of Health with Reference Number BSHRC/PRS/569T/66. Informed written consent was obtained from the participants' parents or caregivers according to CDC [20] guidelines.

2.3. Study Design

A cross-sectional study was carried out on children aged between 1 and 10 years from February to October 2023 in the Pediatrics Units of General Hospital Bayara, Bauchi State, Nigeria.

2.4. Inclusion and Exclusion Criteria

The study included all children who presented with fever and diarrhea or recorded a temperature >37°C in the selected units. Children who tested negative for malaria during screening or had a known medical history of other infections were excluded.

2.5. Sample Size Determination

A total of 666 samples were determined using Andrew Fisher’s formula [21]:

$$Sample\ size = \frac{(Z-score)^2 \times standard\ deviation \times (1-standard\ deviation)}{(Confidence\ interval)^2} \quad (1)$$

Where:
$Z-score$ = 2.58 (99% confidence level)
Standard deviation = 0.5
Confidence interval = 0.01

$$Sample\ size = \frac{(2{,}58)^2 \times 0{,}5 \times (1-0{,}5)}{(0{,}01)^2} = 665{,}64 \ldots \approx 666$$

2.6. Questionnaire Administration

The parents or caregivers of the children enrolled in this study were carefully interviewed using a closed-end structured questionnaire. Demographic data of each child, parent, or caregiver and their hygiene conditions were documented. Information regarding knowledge about malaria and intestinal parasite infections, their transmission, co-infections, and the practices of mothers/caregivers on parasitic infections was also documented. Parents or guardians had to sign consent forms for their children.

2.7. Sample Collection

Stool and blood samples were collected according to Cheesbrough et al. [22]. The samples were then transported (within 2 hours of collection) in a suitable cool box at a standard temperature of 4°C to the laboratory for examination in the Department of Biological Sciences, Faculty of Sciences, Abubakar Tafawa Balewa University Bauchi.

2.8. Laboratory Procedures

2.8.1. Microscopic Examination of Malaria Parasite

Thick and thin blood films were prepared, stained with 10% Giemsa stain, and examined using methods previously described by Njunda et al. [4]. The parasite density was also determined as recommended by Cheesbrough et al. [22].

2.8.2. Stool Examination

Stool samples were collected, prepared, and examined macroscopically and microscopically according to Cheesbrough et al. [23]. The macroscopic examination checked for consistency, color, blood stains (diarrhea), and worms or their segments, while the microscopic examination detected the presence of larvae or ova of intestinal parasite infections. Stool concentration techniques were also used for confirmation. Each specimen was examined using the direct wet mount method with normal saline (0.85% NaCl solution). The Zinc Floatation method (Zinc Sulfate solution) was also carried out on samples that showed negative results on the direct wet mount and examined under a low-power objective of 10× and low light as described by Cheesbrough et al. [23].

2.9. Data Analysis

The data obtained from the questionnaires and parasitological investigations were entered into Microsoft Excel for analysis using IBM Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics, such as proportions and percentages, were computed for demographic data. Associations and relationships between risk factors and disease outcomes were calculated using chi-square and correlation analysis. Statistical significance was set at a confidence interval of 95% with a P-value of < 0.05.

3. Results and Discussion

3.1. Study Population

A total of 666 febrile children were recruited for the study, with 508 (76.3%) meeting the inclusion criteria by providing stool samples and blood specimens. Of these, 381 (53.9%) were males and 285 (46.1%) were females, aged between 1 and 10 years. The prevalence of malaria among the children was 291 (57.3%), while the prevalence of polyparasitism was 217 (42.7%). Males with malaria parasites numbered 158 (54.3%), while their female counterparts were 133 (45.7%). The age group most infected with both malaria and poly parasites was 9-10 years, with 105 (36.1%) and 81 (37.3%) cases, respectively, followed by the 7-8 years age group, with 84 (28.9%) and 41 (18.9%) cases, respectively. The least affected age group was 1-2 years, with 16 (5.5%) and 26 (12.0%) cases, respectively. There was no significant difference in polyparasite infections based on the parents' occupation, primary caretaker, or educational status. Febrile children whose mothers or caregivers attended higher education had the lowest prevalence of polyparasite infections (Table 1).

3.2. Risk Factors of Polyparasitism Infections

The risk factors for polyparasitism infections are shown in Table 2. A chi-square test for independence showed no significant association between toilet facilities and intestinal parasites. However, ownership and utilization of long-lasting insecticidal nets (LLIN) were significantly associated ($p < 0.002$) with malaria infection. Children who regularly slept under treated nets had a lower prevalence of malaria infection than those who did not. There were no associations between malaria infections, intestinal parasites, and risk factors such as water source, deworming activities, and handwashing.

3.3. Prevalence of Malaria and Polyparasitism Based on Species Identified

Plasmodium falciparum (57.3%) was the most prevalent parasitic infection recorded among febrile children, followed by infections with *Ancylostoma duodenale*, accounting for 114 (22.4%), and *Ascaris lumbricoides*, accounting for 79 (15.6%). *Taenia species* were the least prevalent of the intestinal parasitic infections, accounting for 2 (0.4%) cases (Table 3).

3.4. Prevalence of Malaria and Polyparasitism According to Communities of Febrile Children

Birshi-Gandu had the highest prevalence of malaria and polyparasitism, accounting for 86 (29.6%) and 54 (24.9%) cases, respectively. The Baram community accounted for 43 (14.8%) and 31 (14.3%) cases, respectively. Yelwan Lebura had the lowest prevalence of parasitic infection, accounting for 19 (6.5%) cases. There was no significant difference ($p > 0.340$) in the prevalence of malaria and intestinal parasite infections across the communities (Table 4).

3.5. Prevalence of Polyparasitism

A total of 217 (42.7%) febrile children were infected with polyparasitism. The most prevalent double parasitic infections were *Plasmodium falciparum* and *Ancylostoma duodenale*, accounting for 131 (60.4%) cases. Besides that, *P. falciparum* and *A. lumbricoides* with 32 (14.7%) cases, *P. falciparum* and *Taenia species* with 24 (11.1%) cases, and *P. falciparum* and *Entamoeba histolytica* with 17 (7.8%) cases. The least common triple parasitic infections were *P. falciparum, Taenia species,* and *E. histolytica*, accounting for 3 (1.4%) cases. The least common quadruple parasitic infections were *P. falciparum, E. histolytica, A. lumbricoides,* and *A. duodenale*, accounting for 1 (0.5%) case (Table 5).

Table 1. Distribution of malaria and polyparasitism among febrile children according to their demographic profile.

Demographic	No. of sample	No. (%) of children with malaria ($n = 291$)	No. (%) of children with polyparasitism ($n = 217$)
Gender			
Male	381	158 (54.3)	116 (53.4)
Female	285	133 (45.7)	101 (46.5)
Age (years)			
1 – 2	116	16 (5.5)	26 (12.0)
3 – 4	111	46 (15.8)	33 (15.2)
5 – 6	124	40 (13.7)	36 (16.6)
7 – 8	146	84 (28.9)	41 (18.9)
9 – 10	169	105 (36.1)	81 (37.3)
Education			
Not started	213	136 (46.7)	96 (44.2)
Nursery	252	103 (35.4)	72 (33.2)
Primary	201	52 (17.9)	49 (22.6)
Occupation of the parents			
Farmers	218	141 (48.5)	102 (47.0)
Trader/Artisans	189	83 (28.5)	64 (29.5)
Civil servant	259	67 (23.0)	51 (23.5)
Primary caretaker			
Parents	233	163 (56.0)	98 (45.2)
Grandparents	204	41 (14.1)	61 (28.1)
Others	229	87 (29.9)	58 (26.7)

Table 2. Distribution of polyparasitism according to risk factors of the diseases in the study area.

Variables	Polyparasitism ($n = 217$)	Prevalence	p-value
Toilet system			
Pit latrine	146	(67.3)	0.023
Modern	71	(32.7)	
Water source			
Tap water	51	(23.5)	0.145
Well/borehole	64	(29.5)	
Stream/river	102	(47.0)	
Deworming			

Variables	Polyparasitism ($n = 217$)	Prevalence	p-value
Regularly	76	(35.0)	0.267
Not regularly	141	(65.0)	
LLIN usage			
Regularly	62	(28.6)	0.002
Not regularly	155	(71.4)	
Handswashing			
Regularly	54	(24.9)	0.441
Not regularly	163	(75.1)	

Key: LLIN = Long Lasting Insecticidal Nets

Table 3. Prevalence of malaria and polyparasitism based on species identified in the children in the study area.

Parasites	No. of infected children ($n = 508$)	Prevalence (%)
Malaria parasites		
Plasmodium falciparum	291	(57.3)
Plasmodium vivax	00	(0.0)
Plasmodium ovale	00	(0.0)
Plasmodium malariae	00	(0.0)
Intestinal parasites		
Ancylostoma duodenale	114	(22.4)
Ascaris lumbricoides	79	(15.6)
Entamoeba histolytica	17	(3.3)
Taenia specie	2	(0.4)
Giardia lamblia	5	(1.0)

Table 4. Prevalence of malaria and polyparasitism according to communities of febrile children in the study area.

Demographic	No. of sample ($n = 666$)	No. (%) of children with malaria ($n = 291$)	No. (%) of children with polyparasitism ($n = 217$)	No. (%) of children with malaria and polyparasitism ($n = 508$)
Baram	102	43 (14.8)	31 (14.3)	92 (18.1)
Birshi-gandu	155	86 (29.6)	54 (24.9)	114 (22.4)
Gwallameji	50	4 (1.4)	10 (4.6)	20 (4.0)
Kafin Tafawa	66	28 (9.6)	22 (10.1)	47 (9.3)
Lushi	63	24 (8.2)	19 (8.8)	56 (11.0)
Tsakani	70	37 (12.7)	26 (11.9)	48 (9.4)
Rafin Zurfi	52	29 (10.0)	21 (9.7)	43 (8.5)
Wurogwabbo	55	21 (7.2)	20 (9.2)	52 (10.2)
Yelwan Lebura	53	19 (6.5)	14 (6.5)	36 (7.1)

P value = 0.340 (at confidence interval of 0.01)

Table 5. Distribution pattern of polyparasites among febrile children in the study area.

Parasite combination	No. of infected children ($n = 217$)	Prevalence (%)
Pf + An	131	(60.4)
Pf + As	32	(14.7)
Pf + Ts	24	(11.1)
Pf + En	17	(7.8)
Pf + As + An	5	(2.3)
Pf + Gl + En	4	(1.8)
Pf + Ts + En	3	(1.4)
Pf + En + As + An	1	(0.5)

Key: Pf: *Plasmodium falciparum*; As: *Ascaris lumbricoides*; An: *Ancylostoma duodenale*; Ts: *Taenia specie*; En: *Entamoeba histolytica*; Gl: *Giardia lamblia*.

Table 6. Seasonal variation of malaria and polyparasitism among febrile children in the study area.

Seasons	No. examined children ($n = 666$)	No. (%) of children with malaria ($n = 291$)	No. (%) of children with polyparasitism ($n = 217$)	No. (%) of children with malaria and polyparasitism ($n = 508$)
Dry	312	112 (38.5)	94 (43.3)	213 (41.9)
Wet	354	179 (61.5)	123 (56.7)	295 (58.1)

3.6. Prevalence of Malaria and Polyparasitism According to Seasons

Plasmodium falciparum malaria had a higher prevalence across the seasons, accounting for 179 (61.5%) cases in the wet season and 112 (38.5%) in the dry season. Polyparasitism was also higher in the rainy season, accounting for 123 (56.7%) cases, compared to 94 (43.3%) cases in the dry season. The results revealed that febrile children had a higher prevalence of malaria and polyparasitism in the rainy season (295 or 58.1%) compared to the dry season (213 or 41.9%) (Table 6).

3.7. Discussion

The prevalence of polyparasites (including malaria and intestinal parasites) was 76.3% of polyparasites infection in the study area, which is higher compared to the findings of 50.7% reported by Albonico et al. [24] in children in the Southwest Region of Cameroon. 40.6% in the Centre Region of Cameroon [25], 38% of the children were infected with two or more parasites [26], 33.8% in Limbe and Buea [16], and in coastal Kenya in which a prevalence of 31.80% was also recorded [27]; the poly parasites prevalence found by this work was high, which is a display of endemic presence of polyparasitic infections in the observed area. The results could easily be attributed to supportive climatic conditions (such as soil moisture, climate, warm temperature, poor sanitation, unhygienic conditions, poor economic status, and others) for disease transmission [28]. Datoo et al. [29] argue that parasitic infections, such as malaria, directly display prevalence linked to the nature or state of the environmental conditions in the given area. That is why malaria is more commonly transmitted during the rainy season. This work was conducted during rainy and dry seasons; this might also be behind the elevated intestinal parasitic prevalence depicted by this study's findings. However, other determinants, such as poverty, illiteracy, and poor WASH, can cause a rise in the prevalence of diseases [30-32]. Similarly, a related work by Hurlimann et al. [30] showed children been infected by more than one parasitic disease. However, no significant difference in the prevalence of polyparasitism was found across communities ($p > 0.340$).

The polyparasitism tendency may increase with age; in addition, older children (9-10 years) were more affected by the infection than children 1-2. Therefore, this night occurred because the older ones were more mindful of hygiene practices and more active. The prevalence of polyparasitism was observed in males more than females, which may be because the gender roles of males make them more active in disparate activities that allow more contact between humans and infective stages of the parasites. Additionally, disparate geography could explain the difference in the prevalence rate of males and females in the observed areas [4, 33-34]. Related worlds reported from other nations indicated malaria prevalence (*P. falciparum*) as high as 57.3 per cent [35]. 28.8% prevalence was related to the Southern part of Ethiopia in [4], 29.8% related to Tanzania [36], as well as 11.5% found in Northwest Ethiopia [37].

4. Conclusion

In conclusion, the study revealed a very high prevalence of *Plasmodium falciparum* of malaria species and a relatively lower prevalence of intestinal parasite infections: *Ancylostoma duodenale, Ascaris lumbricoides, Entamoeba histolytica, Taenia specie,* and *Giardia lamblia* among febrile children in the study area. Therefore, the Prevalence of Polyparasitism with Malaria and Intestinal parasite infections detected in this study was inconclusive. Hence, there is a need for further investigation to obtain reliable estimates of malaria and intestinal parasitic infections from areas of elevated transmission. Consequently, this yields promising evidence that guides the development of better interventions addressing the pressing issues in implementing strategies.

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