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STUDIES ON THE EPIDEMIOLOGY OF *PLASMODIUM* AND *SCHISTOSOMA* INTENSITIES AMONG RIVERINE COMMUNITIES IN MAKURDI, BENUE STATE, NIGERIA

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Abstract: Malaria and schistosomiasis are two of the most frequent illnesses with public health implications in tropical and subtropical endemic countries. This study aimed to determine the intensities of *Plasmodium* and *Schistosoma* infections in riverine communities in Makurdi, Benue State, Nigeria. A cross-sectional study was designed, and a total of 1,060 blood, urine, and stool samples were collected for the analysis, and 720 were analysed for *Plasmodium* parasites and *Schitosome* eggs using standard laboratory methodologies and techniques. The highest intensity was found in *Schistosoma haematobium* (6.12), followed by *P. falciparum* (5.6), and the lowest was found in *Schistosoma mansoni* (4.33). According to sex and age-related intensities, females had the highest intensity (5.00) of *P. falciparum* in the 1–10-year age range. Males had a higher *S. haematobium* intensity (4.43) than females (2.75). In the different riverine populations, the intensities of *P. falciparum*, *S. haematobium*, and *S. mansoni* did not differ significantly ($P > 0.05$). Finally, among riverine villages in Makurdi, Benue State, Nigeria, the overall intensity of *Plasmodium falciparum, Schistosoma haematobium*, and *Schistosoma mansoni* is 489 (6.89), 476 (5.60), and 448 (5.21), respectively. According to the researchers, infected volunteers should be treated with anti-malarial medications for malaria and praziquantel for schistosomiasis.

Keywords: Malaria; Schistosomiasis; School age; Riverine communities; Makurdi-Nigeria

Introduction

Malaria and schistosomiasis are two of the most frequent illnesses in tropical and subtropical countries, posing serious public health risks (Doumbo *et al*., 2014). Malaria is a life-threatening parasitic disease spread by insects and caused by a *Plasmodium protozoan* parasite (Getie *et al*., 2015). Malaria is linked to anaemia, which leads to significant morbidity and mortality in *Plasmodium falciparum*-infected people (Ajakaye and Ibukunoluwa, 2020). *P. vivax, P. ovale,* and *P. malariae* are other human-infecting species. Malaria risk factors include a lack of use of mosquito nets, indoor residual spray, and the presence of several mosquito breeding sites or stagnant water near the home and spending the night outside (Doumbo *et al*., 2014). On the other hand, schistosomiasis is a disease caused by digenic trematode flatworms (Okpala *et al*., 2004). In terms of socioeconomic and public health importance in tropical and subtropical countries, it is only second to Malaria (Okpala *et al*., 2004). It's also the most common waterborne infection and one of the most significant health risks in rural, underdeveloped countries (Okpala *et al*., 2004). The risk factors connected with schistosomiasis include a lack of safe drinking water, contact/exposure to freshwater bodies, outdoor activities, low socioeconomic position, and limited educational access (Getie *et al*., 2015).

Malaria and schistosomiasis are endemic, and co-infection is common, resulting in more severe clinical symptoms and pathology. Fever, chills, nausea, abdominal pains, and joint pains are common with malaria, while haematuria, dysuria, abdominal pains, bloody diarrhoea in stool, cough, headache, rash, body ache, and fever are associated with schistosomiasis. Schistosoma species infection is prevalent in school-aged and riverine communities, as it is easily obtained while bathing or swimming in water polluted with cercaria, which is shed by intermediate host snails and infects people by entering the human epidermis (Kabatereinen *et al*., 2004). One of the most critical risk factors for malaria preexposure is the season and history of travel (WHO 1994).

Malaria is usually detected through a microscopic study of blood films or antigen-based fast diagnostic procedures (RDT). The fact that each of the four primary parasite species has distinct characteristics, microscopic examination of blood films is the most cost-effective, popular, and reliable method of diagnosing malaria. Malaria treatment is determined by the type of infection, the severity of the illness, the host's status, and any related disorders or diseases. (World Health Organization and USAID, 1999; Claire *et al*., 2004; McCutchan *et al*., 2008).

Clinical signs and symptoms, a history of living in and travelling to an endemic area, serological tests, and the presence of the distinctive eggs with a terminal spine in urine are used to diagnose *S. haematobium* infection. Cystoscopy and ultrasonography can both reveal complications. Serological tests are highly effective during the pre-patent phase and in chronic situations where eggs cannot be found. Serological assays used to diagnose *S. mansoni* infection can also diagnose *S. haematobium* infection. Microscopic detection of the characteristic eggs with a terminal spine in urine and occasionally in faeces is the most common and conclusive method of diagnosis (Cheesbrough, 1998; Marquardt *et al.*, 2000).

Epidemiologic studies on malaria and schistosomiasis co-existence in tropical and sub-tropical endemic regions are common (Adegnika and Kremsner, 2012). However, similar research is scarce in Benue state, Nigeria. As a result, the present study was designed to determine the intensities of *Plasmodium* and *Schistosoma* infections in riverine settlements in Makurdi, Benue State, Nigeria.

Materials and Methods

Study Area

Makurdi, Benue state capital, is situated at latitude 7° 41 N and longitude 8° 28 E. Makurdi is located on the Benue River, which has a length of around 671 meters (Udo, 1981). The rainy season lasts seven months (April to October), with yearly rainfall ranging from 1,200 to 2,000mm (Akaahan *et al*., 2010). Peak flows occur from August to early October, while low levels occur from December to April, depending on the rainy season. Intensive agricultural activity, bathing, swimming, and washing in rivers and streams are all common (Houmsou *et al*., 2012). The area has high temperatures ranging from 28 to 33 degrees Celsius throughout the year, with March and April being particularly hot. Harmattan winds bring a cooling influence (Houmsou *et al*., 2012).

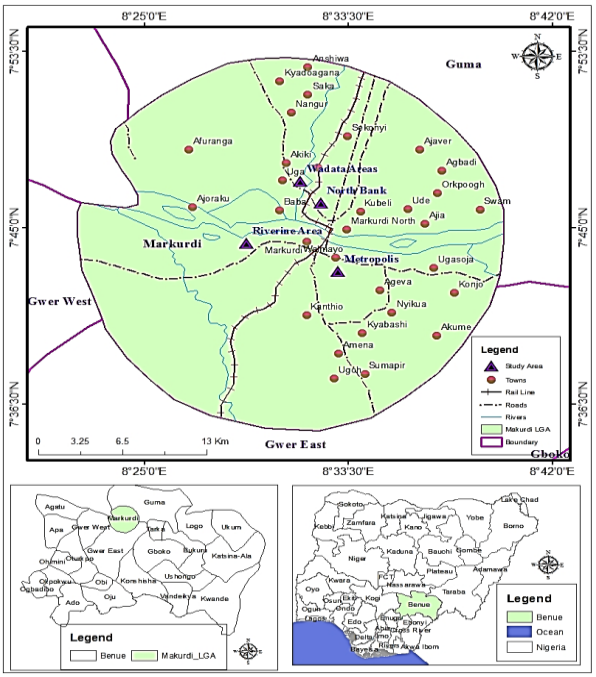

Figure 1: Modified Administrative Map of Benue State indicating study locations

Sample Size Determination

The sample size (n = 720) was estimated using the modification formula ($n = Z^2(1-p)/L^2$) Kogi, (2015). Where: n = is the sample size required, Z = The normal distribution at 95% confidence interval, P = Proportion of infected individuals on a scale of 1, q = (1-p) = Proportion of infection-free individuals on a scale of 1, L = Precision level on a scale of 1.

Ethical Considerations

The Benue State Ministry of Health, the Federal Medical Centre in Makurdi, the Local Government Education Authority, the Riverine Communities Head, and the approval of parents of school students were all obtained before the study.

Study Design

Participants were chosen from each school and the riverine communities using a cross-sectional study design and random sampling. Seven hundred twenty participants were selected by random sample from each school and the riverine settlements.

Study Population

Seventeen schools and three (3) riverine towns were chosen randomly for their proximity to a water source.

Inclusion Criteria

Primary 1-6 pupils between the ages of 6 and 14 and secondary school students between 15 and above were recruited. In addition, people of various ages from the riverine communities were enlisted. As far as the goal of this study is concerned, each pupil's anonymity was protected with extreme caution.

Sample Collection

A total of 1,060 blood, urine, and stool samples were collected from the participants. Their demographic characteristics such as gender and age were recorded at the time of collection. The samples were collected in sterile urine sampling bottles and anticoagulant blood sampling bottles (EDTA bottles) between 7 a.m. and 10 a.m. and delivered to the Federal Medical Centre Makurdi laboratory for examination (Cheesbrough, 2006; Nyarko *et al*., 2018).

Laboratory analysis of Samples

Microscopic Assessment of Plasmodium Detection

Two drops of venous blood were placed separately on a microscopic glass slide, as Nyarko *et al*. (2018) adopted. Thick and thin blood films were prepared and air-dried. Thin blood films were fixed with absolute methanol, and both films were stained with 10 % Giemsa stain for 10 min. Then both thin and thick blood films were examined using a light-camera microscope (LEICA DM 2500 model) with a ×100 objective lens for the presence of malaria parasite. And the density of the parasite was counted as "Number Parasites Found" (NPF) using recommendations of WHO standards. The thick film relies on the parasitised RBCs against leukocytes (WBCs). The number of leukocytes (WBCs) used is 8000 (WHO, 1991). In addition, two tally counters (one to count parasites and the other to count leukocytes and a simple electronic calculator) were used and expressed by this formula.

$$\frac{\text{Number of parasites counted} \times 8000}{\text{Number of leukocytes (WBCs)}} = \text{Parasites per microliter} \quad \ldots\ldots(1)$$

Analyses of Urine Samples for Schistosome Detection

Reagent strips combi-9 and combi-10 (Medi-Test Macherey-Nagel, Germany) were dipped into each urine sample to determine the presence of blood, and the colour was matched to the standard colour on the side of the container, as instructed by the manufacturer. Urine samples were tested for the presence of eggs using the sedimentation technique. Each urine sample was carefully shaken before being decanted into a test tube and centrifuged at 3000 rpm for 5 minutes in a hematocrit centrifuge machine, with the supernatant being discarded and the sediments remaining. A sediment drop was placed on a clean microscope slide and stained with Lugol's iodine. The stain was allowed to penetrate the eggs for 15 seconds before being observed under a microscope at low power (10) and then a 40-objective lens (Cheesbrough, 2002). For each positive sample, the number of *S. haematobium* eggs per 10 mL of urine was counted, and the intensity was calculated by multiplying the crude egg numbers per slide by the number of mL of the corresponding urine sample and dividing by 10. Values greater than fifty (50) *S. haematobium* eggs per 10 mL were considered a high-intensity infection (WHO, 1991 and WHO, 2011). *S. haematobium* is identified by the presence of a terminal spine.

Evaluation of Stool Samples for Schistosome Detection

About 1–2 mg of the stool sample was emulsified in a drop of normal saline (0.85 percent NaCl) on the middle of the slide using a disinfected stick, as recommended by WHO (1991), WHO (2011), Solomon *et al*., (2013) and Rasoamanamihaja *et al*., (2016). The material was covered with a coverslip and inspected with 10 and 40 objective lenses. An estimated 1 g (pea-size) of typical faeces was emulsified in roughly 4 ml of 10% formol water contained in a screw-cap tube using a disinfected stick. Then 3–4 ml of 10% w/v formol water was added and thoroughly mixed by shaking. The gauze was used to sift the emulsified faeces, and the suspension was then transferred to a centrifuge tube. 3–4 mL diethyl ether was then added. After 1 minute of capping and mixing, the tube was centrifuged at 3000 rpm for 1 minute. After centrifugation, the faecal debris was isolated between the diethyl ether and the 10% formal-saline layers. A sterilised wooden stick was used to dislodge a layer of faeces waste, and the tube was quickly inverted to discard the ether, faecal debris, and formol water. To re-suspend and mix with the sediment, the bottom of the tube was tapped. Finally, the sediment was put on a slide, and a cover glass was placed over it. Next, the preparation was inspected under a microscope with the 10 and 40 objective

lenses. *S. mansoni* is identified by the presence of a lateral spine. WHO (2011) procedures were utilised to determine the severity of the *S. mansoni* infection. By filling a Kato-Katz template on two distinct slides with stool (Kato-Katz kit, Vestergaard-Frandsen, Lausanne, Switzerland), levelling, and covering each sample with a cellophane slip pre-stained with methylene blue, two slides per each stool sample were generated (Katz, and Pellegrino, 1972). The eggs of *Schistosoma mansoni* were detected on the stool slides within 60 minutes. According to producer instructions, the number of eggs per gram (EPG) of stool was estimated by multiplying the crude egg number per slide by 24. (WHO, 2011). The severity of the illness was divided into three categories based on the egg per gram (EPG) of feacal samples: EPG stands for egg per gram of faeces. Light: 1 to 99 EPG, Moderate: 100 to 399 EPG, Heavy: > 400 EPG.

Data Analysis

The distribution frequency and intensities of *Plasmodium* and *Schistosoma* species were determined using descriptive statistics. The Chi-Square test was performed to examine the relationship between Plasmodium and Schistosoma species and demographic parameters.

Results and Discussion

The sex and age-associated Intensity of Plasmodium and Schistosoma Species in Ankpa Wadata Ward Riverine Communities in Makurdi, Benue State, Nigeria, is shown in Table 1. The maximum intensity was found in *S. haematobium* (6.12), followed by *P. falciparum* (5.6), and the lowest intensity was found in *S. mansoni* (4.33). Sex and age-associated intensity found that males had the highest (3.33) of *P. falciparum* among the 1–10 age groups, while females had the lowest (3.22). The highest intensity of *S. haematobium* (6.00) was found in men, while the lowest intensity (5.20) was found in females. The highest intensity (3.00) of *S. mansoni* was found in males, while the lowest (0.00) was found in females. Males had the highest intensity (4.92) of *P. falciparum* between 11 and 20 years, whereas females had the lowest (3.93). The highest intensity of *S. haematobium* (8.00) was found in men, whereas the lowest intensity (6.25) was found in females. The highest *S. mansoni* intensity (5.00) was found in males, while the lowest (4.00) was found in females. Males had the highest intensity (12.25) of *P. falciparum* in the 21–30-year period, whereas females had the lowest (6.00). The highest intensity of *S. haematobium* (7.00) was found in males, while the lowest intensity (6.57) was found in females. Males and females both had the same intensity (5.00) of *S. mansoni*. Males had the highest intensity (13.71) of *P. falciparum* in the 31–40-year period, whereas females had the lowest (4.54). Males had the highest concentration of *S. haematobium* (7.33), while females had the lowest (5.17). Females had the highest intensity of *S. mansoni* (5.00), while none was found in males. The intensity of *P. falciparum* and *S. mansoni* did not differ statistically significantly (P > 0.05). In the current study, *S. haematobium* has a statistically significant difference (P 0.05).

Table 1: Sex and Age Associated Intensity of *Plasmodium* and *Schistosoma* Species among Ankpa Wadada Ward Riverine Community in Makurdi, Benue State, Nigeria

	Number examined	*Plasmodium falciparum*			*Schistosoma haematobium*			*Schistosoma mansoni*		
Sex/age group		Infected	Parasite counts	Intensity	Infected	Egg counts	Intensity	Infected	Egg counts	Intensity
1 – 10 Years										
Male	30	9	30	3.33	2	12	6.00	1	3	3.00
Female	31	9	29	3.22	6	31	5.20	0	0	0.00
11 – 20 Years										
Male	37	13	64	4.92	2	16	8.00	1	5	5.00
Female	37	15	59	3.93	8	50	6.25	1	4	4.00
21– 30 Years										
Male	20	8	98	12.25	2	14	7.00	1	5	5.00
Female	34	13	78	6.00	7	46	6.57	1	5	5.00
31 – 40 Years										
Male	19	7	96	13.71	1	8	7.33	0	0	0.00
Female	32	11	50	4.54	6	31	5.17	1	4	4.50
Total	**240**	**85**	**476**	**5.60**	**34**	**208**	**6.12**	**6**	**26**	**4.33**
t-test P-value			**P = 0.43**				**P = 0.05**			**P = 0.50**

The Sex and age-associated Intensity of *Plasmodium* and *Schistosoma* Species in Clerk/Market Ward Riverine Communities in Makurdi, Benue State, Nigeria, are shown in Table 2. The maximum intensity was found in *P. falciparum* (5.21), followed by *S. haematobium* (4.38), and the lowest intensity was found in *S. mansoni* (2.00). Sex and age-associated intensity found that females had the highest intensity (5.00) of *P. falciparum* in the 1–10-year age group, whereas males had the lowest intensity (4.11). *S. haematobium* was found to have the highest intensity (3.00) in males and the lowest (2.75) in females. Males had the highest *S. mansoni* intensity (2.50), while females (1.50). Males had the highest intensity (6.00) of *P. falciparum* in the 11–20-year-old age group, whereas females had the lowest (5.50). Females had the highest concentration of *S. haematobium* (4.43), while males had the lowest (3.00). *S. mansoni* was found to have the same intensity (2.00) in males and females.

Males had the highest intensity (5.56) of P. falciparum in the 21–30-year-old age group, whereas females had the lowest (5.18). Females had the highest concentration of *S. haematobium* (6.43), while males had the lowest (3.80). Females had the highest S. mansoni intensity (2.25), whereas males had the lowest (1.50). In the 31–40-year-old age range, males had the highest P. falciparum intensity (4.80), while females had the lowest (4.29). Females had the highest S. haematobium intensity (5.25), whereas males had the lowest (3.30). *S. mansoni* was found to have the highest intensity (3.00) in males and the lowest (1.50) in females. The intensity of *P. falciparum*, *S. haematobium*, and *S. mansoni* in the different riverine populations did not differ statistically significantly (P 0.05).

Table 2: Sex and Age AssociatedIntensity of *Plasmodium* and *Schistosoma* Species among Clerk/Market Ward Riverine Community in Makurdi, Benue State, Nigeria

	Number examined	*Plasmodium falciparum*			*Schistosoma haematobium*			*Schistosoma mansoni*		
Sex/age group		Infected	Parasite counts	Intensity	Infected	Egg counts	Intensity	Infected	Egg counts	Intensity
1 – 10 Years										
Male	26	9	37	4.11	3	9	3.00	2	5	2.50
Female	24	6	30	5.00	4	11	2.75	2	3	1.50
11 – 20 Years										
Male	29	12	72	6.00	4	12	3.00	2	4	2.00
Female	28	8	52	6.50	7	31	4.43	2	4	2.00
21– 30 Years										
Male	38	16	89	5.56	5	19	3.80	2	3	1.50
Female	36	11	57	5.18	7	45	6.43	4	9	2.25
31 – 40 Year										
Male	32	10	48	4.80	3	10	3.30	1	3	3.00
Female	32	14	60	4.29	4	21	5.25	2	3	1.50
Total	**240**	**86**	**448**	**5.21**	**37**	**162**	**4.38**	**17**	**34**	**2.00**
t-test P-value				**P = 0.88**			**P = 0.21**			**P= 0.50**

The sex and age-associated intensity of *Plasmodium* and *Schistosoma* species among North Bank II Ward Riverine Communities in Makurdi, Benue State, Nigeria, is reported in Table 3. The maximum intensity was found in P. falciparum (6.89), followed by *S. haematobium* (6.00), while the lowest intensity was found in *S. mansoni* (2.56). According to sex and age-associated intensity, males had the highest intensity (5.83) of *P. falciparum* in the 1–10 year age group, while females had the lowest intensity (3.00). The highest intensity of *S. haematobium* (6.50) was found in men, while the lowest intensity (3.64) was found in females. Males had the highest *S. mansoni* intensity (5.00), while females had the lowest (1.20). Males had the highest intensity (6.44) of *P. falciparum* in the 11–20 year age group, whereas females had the lowest (3.13). The highest intensity of *S. haematobium* (8.00) was found in men, while the lowest intensity (4.31) was found in females. *S. mansoni* was found to have the highest intensity (6.00) in males and the lowest (1.54) in females. Females had the highest intensity (12.12) of *P. falciparum* in the 21–30-year-old age group, whereas males had the lowest (10.64). The highest intensity of *S. haematobium* (14.50) was found in men, whereas the lowest intensity (8.67) was found in females. *S. mansoni* was found to have the highest intensity (9.00) in females and the lowest (5.00) in males. Females had the highest intensity (11.00) of P. falciparum in the 31–40 year age group, whereas males had the lowest (7.14). The highest intensity of *S. haematobium* (14.00) was found in men, while the lowest (8.50) was found in females. The highest *S. mansoni* intensity (7.00) was found in females, whereas the lowest (4.00) was found in men. The intensity of *P. falciparum*, *S. haematobium*, and *S. mansoni* in the different riverine populations did not differ statistically significantly ($P > 0.05$).

Table 3: Sex and Age Associated Intensity of *Plasmodium* and *Schistosoma* Species among North Bank II Ward Riverine Community in Makurdi, Benue State, Nigeria

	Number examined	*Plasmodium falciparum*			*Schistosoma haematobium*			*Schistosoma mansoni*		
Sex/age group		Infected	Parasite counts	Intensity	Infected	Egg counts	Intensity	Infected	Egg counts	Intensity
1 – 10 Years										
Male	23	6	35	5.83	2	13	6.50	1	5	5.00
Female	39	10	30	3.00	11	40	3.64	10	12	1.20
11 – 20 Years										
Male	29	9	58	6.44	3	24	8.00	1	6	6.00
Female	48	15	47	3.13	16	69	4.31	13	20	1.54
21– 30 Years										
Male	27	11	117	10.64	2	29	14.50	3	15	5.00
Female	29	8	97	12.12	3	26	8.67	1	9	9.00
31 – 40 Years										
Male	22	7	50	7.14	2	28	14.00	2	8	4.00
Female	21	5	55	11.00	2	17	8.50	1	7	7.00
Total	**240**	**71**	**489**	**6.89**	**41**	**246**	**6.00**	**32**	**82**	**2.56**
t-test P-value			**P = 0.92**				**P = 0.16**			**P = 0.94**

According to the research, all school students had at least one *Plasmodium falciparum*, *Schistosoma haematobium*, or *Schistosoma mansoni* infection. The intensities of *Plasmodium* and *Schistosoma* species among riverine communities and school-aged children could be as a result of their lack of safe water for domestic purposes, which led to them visiting riverine, outdoor activities, and an open well for a source of water, as well as having multiple mosquito breeding sites around homes and not using mosquito nets or staying outside overnight. According to Rasoamanamihaja *et al*. (2016), Oniya and Olofintoye (2009), the area's proximity to parasite-infected water bodies results in an alarmingly high incidence and intensity of schistosomiasis. As a result, this neglected tropical disease is still endemic in tropical nations, according to Sulyman *et al*. (2009).

Conclusion

Plasmodium falciparum, *Schistosoma haematobium*, and *Schistosoma mansoni* infection rates are 489 (6.89), 476 (5.60), and 448 (5.21), respectively, among riverine settlements in Makurdi, Benue State, Nigeria. As a result, infected participants who received anti-malarial medications for malaria and praziquantel for schistosomiasis should be closely followed. To prevent re-infection, health officials should conduct follow-up therapy regularly. Investigations should be carried out regularly.

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