AJEHS
African Journal of Environmental Health Sciences
Volume 6, November, 2019
http://www.ehsanonline.org
ISSN: 2476-8030
pp 29-36

Seasonal and Environmental Factors Influencing Malaria Parasitaemia amongst Under- Five Children in Elele, Rivers State, Nigeria

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Keywords:
Malaria, Vectors, Parasite, Prevalence, Environmental factors, Under-five children

Mots-clés:
Paludisme, Vecteurs, Parasite, Prévalence, Facteurs Environnementaux, Enfants De Moins De Cinq Ans

Abstract

The influence of seasonal and environmental factors on malaria parasite prevalence was investigated in Elele community, Rivers State, Nigeria. A total of 180 children, aged < 5years were studied and their mothers (women within the reproductive age group)were also recruited as respondents) in the Dry Season(DS) and Rainy Season (RS) respectively. Malaria parasite prevalence was significantly higher in the dry (87.2%) than in the rainy season (62.8%) ($P<0.05$). There was no significant difference between median parasite density in both seasons. Malaria parasite prevalence was higher in the individuals that had stagnant pools of water around their houses in the DS (OR = 12.9, CI= 2.8 – 81.7) and RS (OR= 2.8, CI= 1.2- 6.3). Inhabitants of houses surrounded by bushes also showed higher malaria parasite prevalence compared with those from cleaner surroundings. Environmental sanitation was significantly associated with reduced malaria parasite prevalence (OR=4.0, CI=1.4-9.7). *Anopheles funestus* (92.7%) and *A.gambaie* (7.3%) were vectors associated with perennial transmission of malaria in the area studied with *A. funestus* being predominant. The unusually higher malaria parasite prevalence in the dry season may be attributed to the higher indoor resting density of Anopheles funestus in the dry season. Moreso, lack of environmental sanitation activities may be significant risk factors for the malaria parasite burden in Elele.

Facteurs des saisons et selon l'environnement influençant la parasitémie du paludisme chez les enfants de moins du 5ans à Elele,dans l'Etat de Rivers, au Nigeria

Abstrait

L'influence des facteurs saisonniers et environnementaux sur la prévalence du parasite du paludisme a été étudiée dans la communauté Elele, dans l'État de Rivers, au Nigéria. Au total, 180 enfants âgés de moins de 5 ans ont été étudiés et leurs mères (femmes du groupe d'âge reproducteur) ont également été recrutées comme répondants) en saison sèche (DS) et en saison des pluies (RS) respectivement. La prévalence parasitaire du paludisme était significativement plus élevée pendant la saison sèche (87,2%) que pendant la saison des pluies (62,8%) (P <0,05). Il n'y avait pas de différence significative entre la densité parasitaire médiane au cours des deux saisons. La prévalence parasitaire du paludisme était plus élevée chez les individus qui avaient des flaques d'eau stagnantes autour de leurs maisons dans la SD (OR = 12,9, IC = 2,8 - 81,7) et RS (OR = 2,8, IC = 1,2- 6,3). Les habitants de maisons entourées d'arbustes présentaient également une prévalence plus élevée de parasites du paludisme par rapport à ceux vivant dans des environnements plus propres. L'assainissement a été associé de manière significative à la réduction de la prévalence du parasite du paludisme (OR = 4,0, IC = 1,4 à 9,7). Anopheles funestus (92,7%) et *A. gambaie* (7,3%) étaient des vecteurs associés à une transmission pérenne du paludisme dans la zone à l'étude, avec *A. funestus* prédominant. La prévalence exceptionnellement élevée de parasite du paludisme pendant la saison sèche peut être attribuée à la densité de repos à l'intérieur plus élevée d'Anopheles funestus à l'intérieur pendant la saison sèche. De plus, le manque d'activités d'assainissement de l'environnement peut constituer un facteur de risque significatif pour la charge parasitaire du paludisme à Elele.

Introduction

Malaria is a major public health challenge; the global estimate of malaria is currently 219 million cases with about 92% of these cases occurring in Africa (WHO,2018).It is reported that 94% of malaria-related deaths occur in Africa (Bryce *et al*, 2005) and as such malaria is one of the principal cause of morbidity and mortality in Sub-Saharan Africa including Nigeria (WHO, 2018). In Nigeria, malaria is the leading cause of death in children under five years and of concern is the fact that Nigeria accounts for 25% of the global burden of malaria (WHO, 2018). Available records show that at least 80 per cent of the population of Nigeria suffer from at least one episode of malaria each year; and malaria accounts for over 45 per cent of all out-patient visits (Onwujekwu *et al.*, 2000; WHO, 2009; Aina *et al*., 2013). The disease accounts for 25 per cent of infant mortality and 30 per cent of childhood mortality in Nigeria (Ejezie *et al.,* 1991; Aina *et al*., 2013). Therefore, it imposes great burden on the country in terms of pains and trauma suffered by its victims as well as loss in outputs and cost of treatments (Onwujekwu *et al.,* 2004).

The role of environmental factors on the timing, development, distribution, seasonality and transmission intensity of malaria cannot be overemphasized (Snow *et al.,* 1997; Paul, 1997).

A number of environmental factors such as rainfall, temperature, stagnant pond water, open gutters, and waste amongst others determine the prevalence of malaria and its intensity in given locations (Tukur, 2010). Epidemiologically, mosquito population size and reproductive rate are important components of vectorial capacity that determine the frequency of host contact, the rate of pathogen transmission, and therefore the risk of human infection. The seasonality of malaria is also a major factor in the understanding of the transmission of the disease. Transmission of malaria occurs mainly during the rainy season, which peaks around October although transmission also occurs during the dry season (Toure, 2001).

Previous studies have reported that malaria transmission is perennial with *Anopheles* mosquitoes occurring throughout the year. Factors favouring mosquitoes may include the bushes, garbage heaps, swamps and stagnant pools of water that surround many houses in rural and peri-urban areas (Theresa *et al.,* 2006).

The poor housing conditions present in these areas may also encourage man-vector contact. However, an important tool for optimising malaria control over both time and geographic spread will be a record of malaria seasonality; this could be in form of a risk/ prevalence map as a valuable tool for mapping transmission intensity (Gemperli *et al.*, 2006).

This study therefore investigated the influence of season and environmental factors on malaria parasite prevalence and parasite density in Elele, a peri urban community in River State, Nigeria to provide information that could be used for improving malaria control strategy.

Materials and Methods

Study site

Nigeria experiences only two seasons: the rainy season and the dry season. Rainfall is the determinant factor of seasons in Nigeria, as with most tropical lands. Nigeria's average temperature is 27°C. (Encarta, 2007).

Temperature ranges vary according to the seasons in a year. Elele is a typical evergreen tropical rainforest, and is located at Latitude 5.10167ºN, Longitude: 6.8141417ºE and situated at an elevation/ altitude of 356m. Its average elevation is 352m above sea level. Elele is a transitional area, which comprise of clusters of people settling down in less congested places.

Environmental Health Assessment

Information on various environmental indicators through housing types (the roof, walls, ventilation, flooring, etc.), surrounding environment (stagnant pools of water, bushes/vegetation, refuse dumps, etc., were obtained using an Environmental Health Checklist. Rainfall data was also obtained using the Oregon Scientific Model RGR126 wireless rain gauge.

Entomological survey

Ten volunteer houses representative of the entire community districts were purposively selected for mosquitoes collection. To sample indoor-resting mosquitoes. Mosquitoes were collected in the dry and rainy seasons using the Pyrethrum Spray Catch (PSC) method (WHO 1975). Using plain white sheets spread on the floor around the rooms, spray catches were done in a selected room in each house, with preference to rooms where under-five children slept. The rooms were sprayed with a pyrethrum-based insecticide between 7 and 8 am; 15 minutes after spraying, knocked down adult mosquitoes were collected from the floor sheets. Adult Anophelines were morphologically identified using identification keys (Gillies and De Meillon, 1968). Vector abundance of nuisance mosquitoes and *Anopheles* mosquitoes were also determined.

Parasitological studies

For malaria prevalence studies, 180 under-five participants of both sexes were selected using a five-stage random sampling technique. Ethical clearance was obtained from the Roll back malaria Department at the Local Government Authorities (LGAs). Informed consent were also obtained from mothers of the minors. During the months of December (dry season) 2008 and April (wet season) 2009, blood samples of under-fives were collected by venipucture and thick smears were prepared and stained with Giemsa solution. The slides were observed under 100X objective microscope. Slides were reported negative for parasites only after observing at least 50 fields. Parasite density was determined by counting the number of malaria parasites against 200 white blood cells and expressing the resultant number of parasites/µl blood assuming a white blood cell count of 8000 per µl of blood (WHO, 2016). Malaria parasite prevalence was estimated as percentage of number of individuals who were infected with malaria parasites, of the total sampled.

Statistical analyses

All environmental assessments, entomological and parasitological data were analysed with the Statistical Package for Social Sciences (SPSS). Proportions were compared using the chi-square or t-test. Medians were compared using Mann Whitney U non-parametric test and relationships were assessed using Spearman's correlation. Significant levels were measured at 95% confidence level with significant differences recorded at $p<0.05$.

Results

Metereological Information

During the study (December 2008 to July 2009), the amount of rain increased constantly from January (32.8mm) to June (256.4mm) and dropped in July (222.5mm) (Figure 1).There was a significant difference in mean average rainfall readings measured in the DS (68.6 ± 30.8mm) and RS (205.6 ± 45.6mm). $t = -9.96$, $df = 30$, $p = 0.00$.

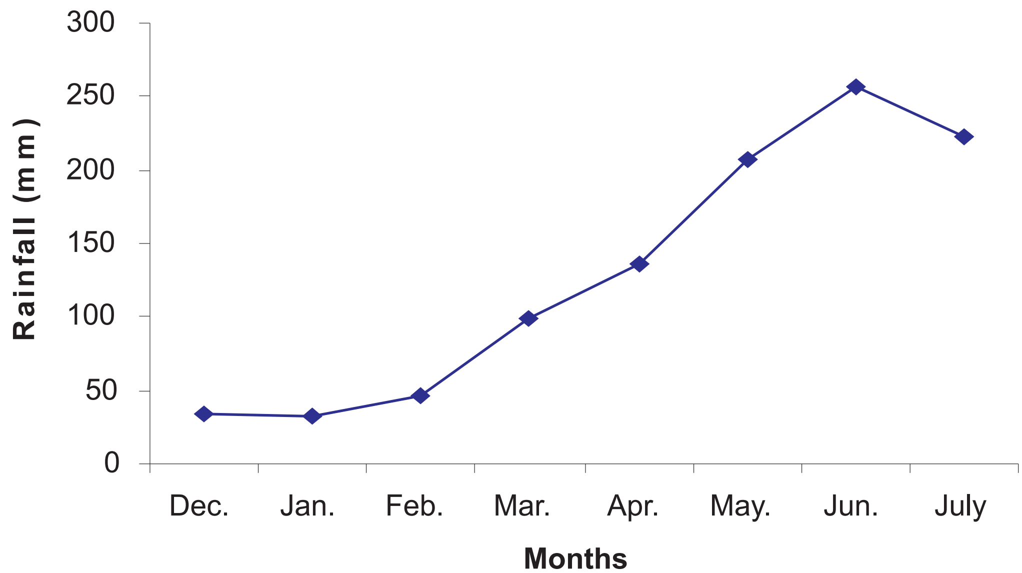

Figure 1: Monthly Rainfall readings (mm)

Environmental Health indicators

Of the 180 houses examined, 88.3% of them used pit latrine as their sanitary facility. More than half of the respondents used the pit for managing wastes and all of the respondents reared domestic animals. A proportion of 71.5% and 69.6% of respondents had stagnant pools of water around their surroundings in the dry and rainy seasons respectively and a higher proportion had bushes surrounding their houses in both DS (72.2%) and RS(83.9%).

Entomological observations

A. funestus and *A. gambiae* were collected in both DS and RS by the spray catch method. Total *Anopheles* species collected were 245 , with 127 catches in the DS and 118 catches in the RS. *A. funestus* was the predominant species caught throughout the year with 123 catches in the DS and 104 catches in the RS. Total *A. gambaie* catches were 4 mosquitoes in the DS and 14 mosquitoes in the RS. The RS recorded more *A. gambiae* catches than the DS, while the DS

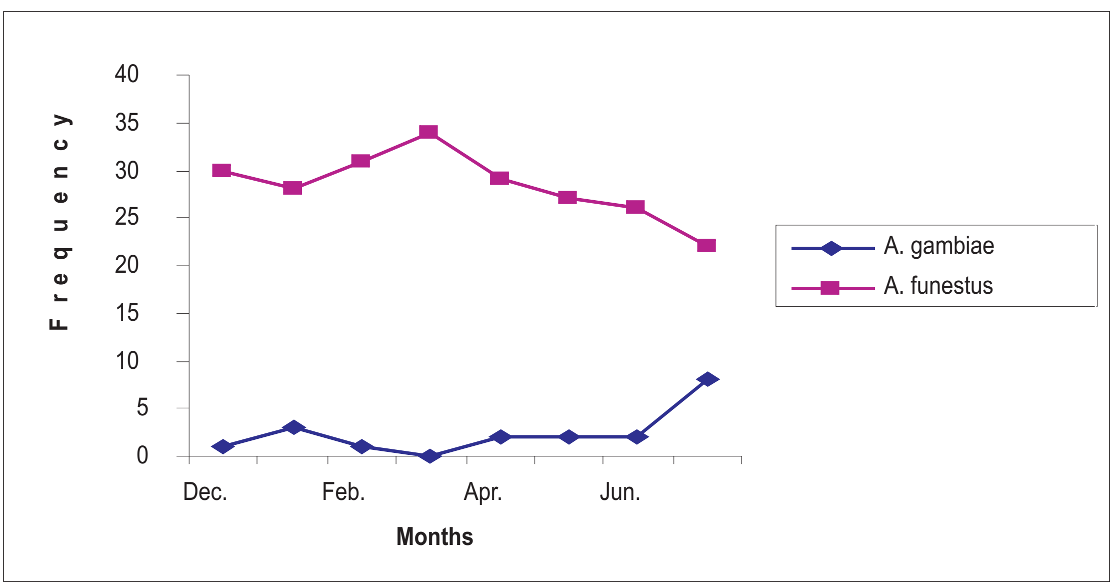

Figure 2: Monthly *Anopheles* – Abundnace

recorded more *A. funestus* catches than the RS (Fig. 2). However the t- test for comparison of mean catches showed a significant difference between mean catches of *A. funestus* in the DS (35.2 ± 4.5, t= 8.42, df = 30, p<0.001) and RS(25.0 ± 1.9, t = 8.4, df = 30, p< 0.001). Also, there was a significant difference in mean catches of *A. gambiae* in the DS (1.3 ± 1.1, t = 3.1, df = 30, p<0.05) and RS(3.50 ± 2.7, t = -3.1, df = 30, p<0.05).

Malaria prevalence and parasite density

Of the 180 under-five children studied, more than half (108, 60.0 %), were females and the rest (72, 40.0 %) males. The mean age of all under-five children was 29 ± 0.89 months(p< 0.01). Seventy-seven respondents (43.5 %) reported that they had 3 - 4 children in a household, while just a few (21, 10.5%) had not less than 5 children in a household. Malaria parasite was prevalent throughout the year but the proportion of under-five children with malaria infection (asexual form of parasites) in the dry season (87.2 %) was significantly higher than that of the rainy season (62.8 %) (Table 1).

The median parasite densities of the dry and rainy seasons were 750 parasites/µL of blood, and 732 parasites/µL of blood respectively. However, the Mann Whitney U non parametric test showed that there was no significant difference between parasite densities in both dry and rainy seasons (p = 0.880) (Table 2).

In terms of the relationship between age of children and parasite, malaria parasite density/ µL of blood seemed to increase as the age of the child increased in both the dry and rainy season and children within the age bracket of 3 had the highest parasite density at both seasons(Fig. 3). However, the Krustal Wallis test shows that there was no significant relationship between malaria parasite density and age of an under-five child in years in the study community. (Chi-square = 1.33, p = 0.724 at df = 3).

Table 1: Seasonal differences in asymptomatic Malaria parasite prevalence

Presence of parasiteamia	Dry season	Rainy season
	N (%)	N (%)
Present	157(87.2)	126 (62.8)
Absent	23(12.8)	54 (30.1)
Total	180 (100.0)	180 (100.0)

Chi-square value= 24.3, df=1, p=0.000

Table 2: Seasonal differences in malaria parasite density

	Median	25 percentile	75 percentile	N
Dry Season	750.00	0.00	1380.00	180
Rainy Season	732.00	300.00	1100.00	180
Total				180

Mann-Whitney U test = 16650.0, p = 0.2

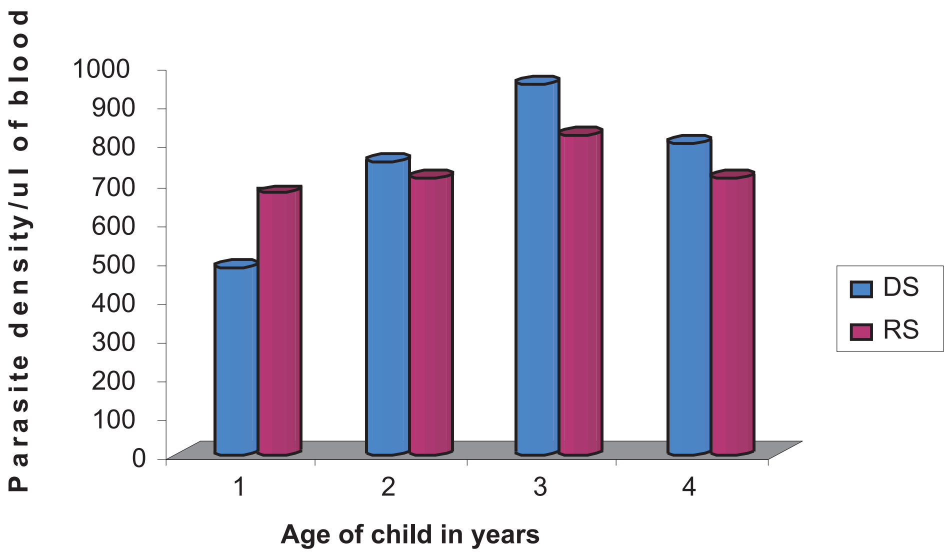

Figure 3: Relationship between age group of under-five and malaria parasite density

Effect of environmental conditions on malaria parasite

Malaria parasite prevalence was higher in children living in houses surrounded by stagnant pools of water and bushes when compared with those inhabiting cleaner environments. Logistic regression analysis showed that in the dry season, those who had pools of water around their houses were 14 times more likely not to have malaria than those who did not (CI = 1.49 – 132.44, p = 0.021). And in the rainy season, they were 12 times more likely to have malaria than those who had no stagnant pool of water around their houses (CI = 2 – 81.73, p = 0.06 df = 1). Those who had overgrown bushes around their houses in the dry season were three times more likely to have malaria than those who did not. (CI = 1.45 – 8.00, p = 0.01).

Respondents whose houses had overgrown bushes in the rainy season were three times more likely to have malaria than those who did not (CI = 1.23 – 6.32, p = 0.14, df = 1). Environmental sanitation was significantly associated with reduced malaria parasite prevalence (OR=4.0, CI=1.4-9.7); as those who practised environmental sanitation activities were 4 times less likely to be infected with malaria parasites ($p < 0.05$).

Discussion

Malaria parasite prevalence was higher in the dry season (87.2%) than in the rainy season (62.8%) in the study community. This clearly differs from results of previous malaria prevalence studies by other researchers. Theresa *et al.,* (2006) in Cameroun, reported malaria parasite prevalence was higher in the RS (50.1%) compared to the DS (40.2%). Malaria parasite density differed in under-five age group but with no significant difference. The study reports no association between age, and malaria parasite density but showed significant relationship between malaria prevalence and sex of child. This agrees with Nas *et al.,* (2017) study that malaria disease was found to "affect more females (54%) than males (46%)". Our report however differs from the report of Adeleke, 2007), which states that "There were no statistical differences in parasitaemia in relation to gender as malaria does not depend on it but rather on the degree of exposure, immunity and availability of infectious female *Anopheles* mosquito.

Entomological surveys conducted in this study revealed that *A. funestus* and *A. gambiae* were the predominant *Anopheline* species and major malaria vectors in Elele community. This findings are similar to findings of the study carried out in Bolifamba, Cameroun.(Theresa *et al*, 2006). In many areas of Africa, *Anopheles gambiae* is found together with an equally important vector *A. funestus*. The seasonal variation in malaria parasite prevalence in Elele can be attributed to changes in *Anopheles* abundance and indoor resting density of *Anopheles* species during the year. The findings of this study confirm that weather and environmental variables have a significant influence on malaria transmission and prevalence amongst children under-five years.

Rainfall played an important role in adult mosquito production but its rise favoured breeding by creating spots. However, the unusual rainfall pattern in the DS produced pools and swamps due to poor drainage, producing suitable conditions for mosquitoes breeding. Constant rains in the RS often washed away breeding sites along with larvae of potential adult mosquitoes, thus leading to reduced anopheles abundance and reduced malaria parasite prevalence during the wet season. However, mosquitoes resort to resting indoors due to warmer temperatures suitable for their stability. These changes in turn modified local mosquito microhabitats and affects transmission widely. The persistence of some stagnant pools, together with the existence of bushes that surround many households in the study area served as resting sites for mosquitoes in both seasons and led to high exposures to mosquito bites and risk of malaria parasite infection the year round. The study points to the usefulness of continuous practice of environmental sanitation to effectively reduce breeding sites and malaria transmission all year round. These results imply that climate changes may alter the distribution and abundance of malaria vectors in the future.

This study further shows that the links between climate and malaria are more complex than previously believed, and hence, the need to take into account regional ecological characteristics in the control of malaria. A reduction of malaria transmission in this area might be achieved by control interventions involving environmental management alongside indoor residual spraying. Such environmental control programmes could be achieved by improving drainage of flooded areas and swamps, as well as through campaigns to clear bushes.

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© *African Journal of Environmental Health Sciences*
Volume 6, November, 2019
ISSN: 2476-8030
pp 29-36