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The Impact of Human and Socio-cultural behavior on malaria transmission in a rural community of Nigeria: The Nyumagbagh Experience

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Abstract: Increase in outdoor feeding and resting of malaria vectors in most African settings where people spend significant time outside at night have allowed vectors to avoid interventions and consequently limit the effectiveness of those known control measures. This study therefore looks at the socio-cultural behavior of humans and their impact on malaria transmission in Nyumangbah Benue State. The study has a cross-sectional and tripod stand design that spans through households (in block house, huts and farm house), non-peri-domestic settings and health facilities. Direct observations, questionnaire based interview and Health Facility records were used concurrently for data collection. Data obtained from this study was entered into MS Excel and analyzed using SPSS version 25 at 5% significance level. Ownership of LLINs was highest, 40.0% among occupants of Block house and least, 12.0% among occupants of farm house ($P < 0.05$). Usage of LLINs was highest, 36.0% among occupants of Block house and least, 8.0% among occupants of farm house ($P < 0.05$). Average sleeping time of 22.00hrs, 22.30hrs and 23.00hrs were recorded for households in block house, huts and farm house respectively. The most reported late outdoor activity was alcohol drinking with 49.3% occurrence while the least reported activity was charging of phones with 22.0% occurrence ($P > 0.05$). *Anopheles* mosquitoes (15 *An. gambiae* s. s., 11 *An. funestus,* 6 *An. coustani* and 1 *An. moucheti*) constituted 30.3% of overall mosquito collections. Members of the *An. gambiae* complex were identified as *An.gambiae* ss using PCR. From the Health Facility record, malaria prevalence of 66.0% was observed. Frequency of malaria occurrence in a year was 17.3%, 55.8% and 26.9% for one, two and three malaria episodes respectively ($P < 0.05$). This study has shown that persistent malaria parasite transmission, possibly due to ineffective use of LLINs can be attributed to the socio-cultural activities of both individuals and community members at large.

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Keywords: Socio-cultural activities, Human behaviour, Malaria, LLINs, Mosquitoes, *Anopheles* species.

Introduction

Malaria has remained a global puzzle particularly for sub-Saharan countries despite all effort to control the disease. The intensity of malaria transmission is exceptionally high in Africa, largely because of abundance of breeding habitats and high vectorial capacity of the major vector species (White *et al*, 2011). The efficacy of current control strategies has slowed in recent years and, more worryingly, for the first time in a decade, malaria incidence is on the rise (Dhiman, 2019).

The free distribution of Long-lasting insecticide treated nets (LLINs) that retain insecticidal activity for 3-5 years for the control of malaria contributed greatly to the reduction of malaria prevalence in rural communities (Kulkarni *et al*., 2010; Egbuche *et al,* 2013). However, progress in malaria control is beginning to level off, with no significant changes in the number of malaria cases or deaths between 2015

and year 2017 (WHO, 2018). While achieving and sustaining high levels of coverage of LLINs is essential, in many context malaria can persist even once these targets have been achieved. Increase in outdoor vector feeding and resting in settings where people spend significant time outside at night may allow vectors to avoid interventions and consequently limit their effectiveness (Durnez and Cooseman, 2013). *Anopheles* mosquitoes biting humans when they are unprotected outdoors is the most obvious of these behaviours (Sougoufara *et al*, 2014). Even when LLINs are used, they may show reduced physical integrity, deterrent effect and mortality effect (Egbuche *et al*., 2019a). While the malaria vector behavior has naturally existed in relation to exophagic and exophilic transmitters, heritably modified behaviours have also been seen by widespread use of LLINs and IRS. This behaviour has resulted in vector populations that can be described as behaviourally resistant in the reality (Killeen and Chitnis 2014).

Socio-cultural practices at both individual and community levels that contribute to outdoor malaria transmission risks need to be well understood for identification and allocation of appropriate intervention to prevent mosquito bites and in turn control malaria. Indeed, the timing of human activities and sleeping behaviors in particular has a strong modulating effect upon human-mosquito contact and the effectiveness of LLINs required in providing personal protection against mosquito bites in specific time and space (Seyoum *et al*, 2013). While behavioural factors are important for individual and household level protection, a range of social and cultural factors are implicated in outdoor mosquito biting and malaria transmission in African communities. This study aimed to identify and explore the impact of human behaviours, socio-cultural practices and the significance of their contributions to exposure and existing outdoor malaria transmission in Nyumangbah, Vandekya Local Government Area of Benue State, Nigeria.

Methodology

Study Area

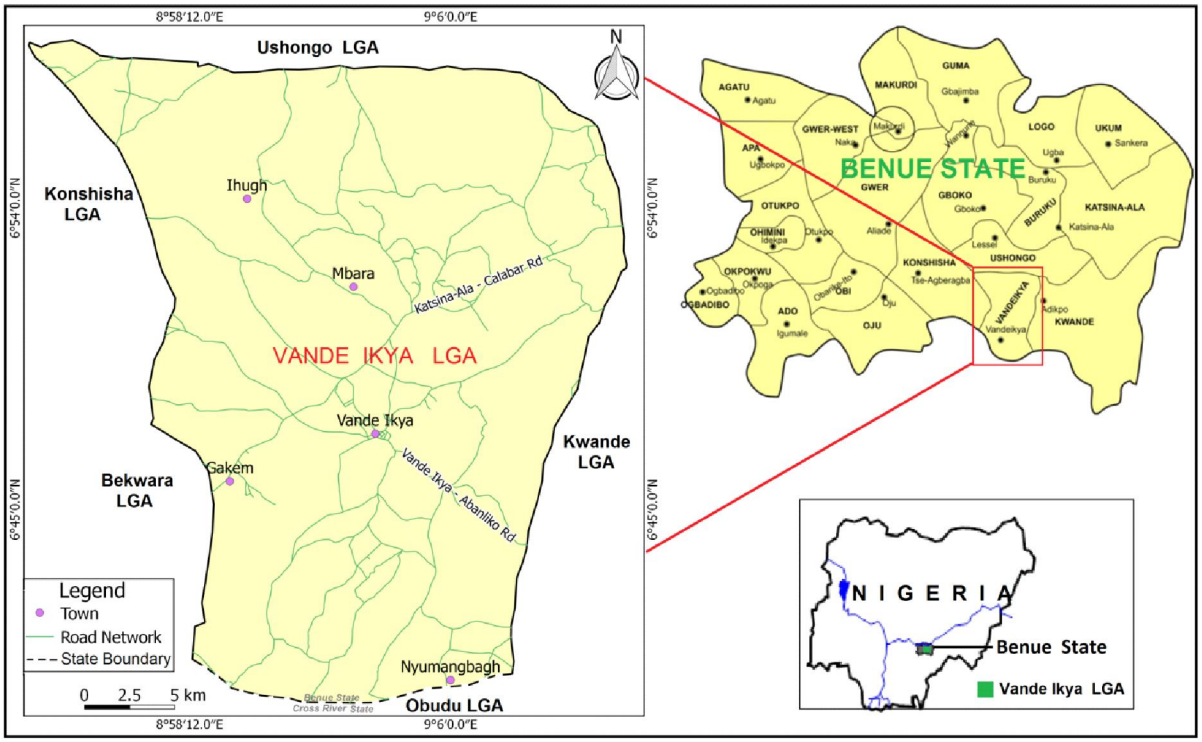

Figure1: Vande Ikya LGA, Benue State showing Nyumangbagh Community

The study was conducted in Nyumagbagh (Lat 6^0659'N and Long 9^009859'E), Vandeikya LGA of Benue State in North- Central Nigeria as seen in (Figure 1). Vandeikya LGA has a projected population of 316,600 (National Population Commission, 2016)) with a landmass of 183,939 square meters (0.7sq miles). Vandeikya is in the South Eastern part of Benue State and shares boundaries with Obudu and Bekwara in Cross River State to the East, Ushongo LGA in Benue State to the North and Konshisha LGA in Benue State to the West. The indigenous community is the Tiv people who speak the Tiv language. Vandeikya Local Government area is dominated by undulating terrain with much of the

land area below 183 m (600 ft) above the sea level. Over 80% of the population are directly engaged in the peasant farming of virtually all major food crops, with concentration on rice, sweet potatoes, cassava, sorghum, citrus, spices, pepper, groundnut and bambara nuts. The housing pattern is mainly Block house, Huts, and farm houses. The Block and Huts houses are mainly cited at the central and clustered area of Nyumangbah while the farm houses were cited some distance around the clustered settlement.

Ethical considerations

Meetings with the Local Government Head, Head of Health Department, community leaders and community members in the study sites were held and the aim and procedures of the study were explained. Consent was obtained from Heads of households to observe the natural behaviour of inhabitants and also to collect mosquitoes from their houses. Participants for in-depth interviews also provided written informed consents. Additionally, consent was obtained from Officer in Charge of the Primary health Centre Ichighi to observe their records on malaria investigations.

Study design

The study has a cross-sectional and tripod stand (Cresswell *et al.,* 2003) designs that spans through households, peri-domestic settings and health facilities. This study involved a quantitative component (in health facility and households) and qualitative component (interviews in household and in non-peri-domestic settings) that were carried out concurrently. For purposes of the study, non-peri domestic settings were settings where people tended to gather away from the observed houses especially in the evenings for example; bars, movie kiosks and cultural or religious gatherings (e.g. weddings and prayer events). Households selected for the study have an average number of 4 persons which majorly included the father, mother and two children or grandparents as most of their household members resides in Makurdi or Obudu and visits home especially for important festivities. Age distribution varied as most of the respondents were from ages 31and above followed by individuals in ages 16 and 30.

Qualitative and quantitative data collection on household characteristics as well as human behaviour and Socio-cultural factors.

A Structured questionnaire for members of 50 households was administered in a quiet, private space, inside or close to the respondent's home. Each questionnaire session lasted between 5-9 minutes. The questionnaire which is basically for the household interview contained the following: number of people in the household, presence of LLINs, time of sleep and the activities keeping persons outdoor before sleeping. In addition to household questionnaire administration, Community leaders were asked to inform the survey team of any night-time gatherings in their communities. There was direct observation and administration of 50 questionnaires to each of three selected known spots in the community where people gather in the evening. These spots included bars and kiosks where people drink and watch football games, market-square and phone charging spot. There was assisted translation of the questionnaire administration from English language to Tiv language, and vice versa. The questionnaire for behaviour of the people in the community has the following content; knowledge of malaria, name of any activity that keeps individual outdoor and when last they suffered malaria.

Quantitative data collection for incidence of malaria

Hospital records were observed from PHC Ikpoikpo Nyumangbagh for malaria prevalence. This retrospective search covered the period from August, 2017 to September, 2018 for monthly prevalence of malaria. The reported malaria cases were diagnosed with Rapid Diagnostic Test kits which has been reported to have similar pattern of performance with microscopy (Egbuche *et al*., 2019b) and recommended by WHO for use in rural settings.

Qualitative and quantitative data collection of malaria vectors in the study area

Three types of houses (block house, hut (yotuho) and farm house) were selected for the entomological survey. CDC light traps were set in and around 3 households out of the fifty (50) households selected for the interview for indoor and outdoor mosquito collections, from 18.00hr to 06.00hr. The collections from the CDC light traps were sorted and identified morphologically. The wings or legs of all mosquitoes morphologically identified as *An. gambiae* s.l. were used for DNA extraction at the Molecular Laboratory of National Arbovirus and Vectors Research Centre Enugu Nigeria. *Anopheles* mosquitoes were differentiated to siblings species level using PCR which was performed with universal and species-specific primers for the *An. gambiae* s.l. Molecular identification of *An. gambiae* species complex is based on the species-specific nucleotide sequences in the ribosomal DNA (rDNA) intergenic spacers (IGS) following the procedure of Scott *et al*., (1993). Five sets of primers designed from the DNA sequences of the IGS region of *An. gambiae* s.l. rDNA were used in PCR for the sibling species identification. The sequence details of the primers are abbreviated, UN primer anneals to the same position on the rDNA

sequences of all five species, GA anneals specifically to *An. gambiae* sensu stricto ME anneals to both *An. merus* and *An.melas*, AR to *An. arabiensis* and QD to *An. quadriannulatus.*

DNA extraction from *An. gambiae* complex

The legs and the wings of each mosquito was placed in a clean 1.5ml Eppendorf tubes and appropriately labeled. Extraction of the DNA was done using Zymo Research kit and the manufacturers' protocol for nucleic acid extraction was followed strictly. The extracted DNA was kept at -20^{o}C.

PCR protocol for *An. gambiae* complex detection.

The primers for the four sub-species of *Anopheles gambiae* s.l. was mixed with 14µl of commercially prepared master mix (from Inqaba biotec West Africa) in a clean 0.2ml PCR tube. PCR water was used to make up the reaction volume to 30µl.

The PCR condition for amplification was programmed as Initial denaturation @94^{o}C for 30 sec, Denaturation @ 94^{o}C for 60 sec, Annealing @68^{o}C for 30 sec, Elongation @72^{o}C for 30 sec, for a total of 40 cycles, final Elongation @72^{o}C for 5mins. The PCR product (Amplicons) was run on 2% Agarose gel for one hour at 120V in an electrophoretic machine to separate the DNA bands. The separated bands were visualized using Dark Reader trans-illuminator.

Data Analysis

Data from the observations, interviews and entomological data were entered into MS Excel and analysized using SPSS version 25.0. Tests for statistical significance were performed at 5% level. Chi-square analysis was used to test for association between house types and each of the household characteristics: gender, age and highest level of education. Chi-square analysis was used to test for association between house types and LLINs ownership, as well as usage. Chi-square analysis was used to test for association between occurrence of malaria and number of episodes in a year. Analysis of Variance was used to compare the frequency of occurrence of different outdoor activities listed by the respondents. Chi-square analysis was used to test for association between outdoor activities stated by the respondents and the peri domestic settings where they gathered. Chi-square analysis was used to compare mosquito abundance in indoor and outdoor locations.

Results

Three hundred and twenty-nine (n=329) persons from the fifty (n=50) households selected for the survey were interviewed and the selected households were divided into (Block house, Huts and Farm House) based on the structure of the houses. The number of respondents in each of the house type is 146 (44.4%) in block house, 131 (39.8%) in hut and 52 (15.8%) in farm house. The number of males in the study was 149 (45.3%) while the number of females was 180 (54.7%). Gender based distribution of the respondents in the different house types is shown in Table 1. There was significant association between gender of the respondents and the house type they live in (P = 0.006).

Age distribution of the respondents showed that 39 (11.9%) respondents were in age group 0 – 5 years, 64 (19.4%) respondents were in age group 6 – 15 years, 112 (34.0%) respondents were in age group 16 – 30 years and 114 (34.7%) respondents were in age group 31 years and above. Age distribution of the respondents in the different house types is shown in Table 1. There was significant association between age of the respondents and the house type they live in (P = 0.000).

Respondents with no formal education were 113 (34.3%) in number, those that attained primary level of education were 101 (30.7%) in number, those that attained secondary education were 92 (28.0%) in number whereas those that attained tertiary education were 23 (7.0%) in number. Distribution of the respondents in the different house types, based on the highest level of education attained is shown in Table 1. There was significant association between the highest level of education attained by the respondents and the house type they live in (P = 0.000). The average sleeping time of the respondents in different house types are equally shown in Table 1.

Table 1: Household Investigation and Characteristics of the study participants in Nyumagbagh, Vandekyia

Variables	Categories	Number of occupants				P - Value
		Block house (%) n = 23	Hut (%) n = 17	Farm house (%) n = 10	TOTAL (%) n = 50	
Gender	Male	67 (45.9)	49 (37.4)	33 (63.5)	149 (45.3)	0.006
	Female	79 (54.1)	82 (62.6)	19 (36.5)	180 (54.7)	

Age	0-5 years	17 (11.6)	11 (8.4)	11 (21.2)	39 (11.9)	0.000
	6-15 years	29 (19.9)	33 (25.2)	2 (3.8)	64 (19.4)	
	16-30 years	33 (22.6)	56 (42.7)	23 (44.2)	112 (34.0)	
	31 and above	67 (45.9)	31 (23.6)	16 (30.8)	114 (34.7)	
Educational status	Non-formal	34 (23.3)	51 (38.9)	28 (53.8)	113 (34.3)	0.000
	Primary	40 (27.4)	43 (32.8)	18 (34.6)	101 (30.7)	
	Secondary	49 (33.6)	37 (28.2)	6 (11.5)	92 (28.0)	
	Tertiary	23 (15.8)	0 (0.0)	0 (0.0)	23 (7.0)	
Average sleeping time	-	22.00 hrs	22.30 hrs	23.00 hrs	-	-

*** Statistically significant at P ≤ 0.05**

Net ownership, access and use Usage

Of the fifty households observed with the average number of 4, 3 and 2 occupants for Block, Huts and farm house respectively, 82.0% of them have at least one bed-net (LLINs) while 64.0% actually slept inside the treated net (LLINs) a day before with their nets still hanging (Table 2). Ownership of LLINs was highest, 40.0% among occupants of Block house and least, 12.0% among occupants of farm house. There was significant difference in LLINs ownership based on house types (P = 0.006). Usage of LLINs was highest, 36.0% among occupants of Block house and least, 8.0% among occupants of farm house. There was significant difference in LLINs usage based on house types (P = 0.003).

Table 2: Net ownership and usage in Nyumangbah

House type	Households		
	Number interviewed	Number that own LLINs (%)	Number that use LLINs (%)
Block house	23	20 (40.0)	18 (36.0)
Huts	17	15 (30.0)	10 (20.0)
Farm house	10	6 (12.0)	4 (8.0)
Total	50	41 (82.0)	32 (64.0)

Malaria episodes from household

Fifty-nine persons were interviewed for the incidence of malaria over the past 12 months and seven of them said they have not suffered from malaria for the period in question. Of the remaining 52 persons, 17.3%, 55.8% and 26.9% of them reported that they have been diagnosed of malaria thrice, twice and once respectively (Table 3). There is significant difference in the number of malaria episode per individual in a space of one year (P = 0.000). Among those that suffered from malaria within the said period, the month of August and December were reported as months with the highest number of occurrence (n = 8).

Table 3: Monthly occurrence of malaria parasitaemia amongst the residents of Nyumangbah

No. of times diagnosed	**Number of people diagnosed of malaria in different months (n = 59)**												**Total (%)**
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Thrice	1	0	1	0	1	2	0	1	1	1	0	1	9 (17.3)
Twice	1	1	2	1	2	2	3	6	3	3	1	4	29 (55.8)
Once	1	0	2	0	0	2	2	1	0	2	1	3	14 (26.9)
TOTAL (%)	3	1	5	1	3	6	5	8	4	6	2	8	52

Predominant Outdoor Activities in Nyumangbah

The socio-cultural and economic activities keeping people outdoors in the study area are shown in Table 4. The most reported activity was alcohol drinking with 49.3% occurrence while the least reported activity was charging of phones with 22.0% occurrence. However, there was no significant difference in the frequency of occurrence of different outdoor activities listed by the respondents (P =

0.263). In Bars and Kiosk, the most occurring response from the people that gathered there was alcohol drinking (n = 33) while the least responses were watching of football matches (n = 9) and post – harvest processing (n = 9). In the phone charging spot, the most occurring response from the people that gathered there was alcohol drinking (n = 22) while the least response was marriage celebrations (n = 8). In the market, the most occurring response from the people that gathered there was trading (n = 34) while the least response was charging of phones (n = 4). There was significant association between outdoor activities stated by the respondents and the peri domestic settings where they gathered (P = 0.000).

Table 4: Predominant Socio-cultural and economic activities keeping the people outdoors in Nyumangbah

Outdoor activities	Number of Responses from people found in the selected Non-peri-domestic setting				
	Bars and Kiosks (%) n = 50	Phone charging spot (%) n = 50	Market (%) n = 50	Total (%) n = 150	mean±se
Charging of phone	15 (30.0)	14 (28.0)	4 (8.0)	33 (22.0)	11.0±3.5
Marriages	13 (26.0)	8 (16.0)	18 (36.0)	39 (26.0)	13.0±2.9
Burials	11 (22.0)	19 (38.0)	22 (44.0)	52 (34.7)	17.3±3.3
Watching Football	9 (18.0)	17 (34.0)	10 (20.0)	36 (24.0)	12.0±2.5
Drinking alcohol	33 (66.0)	22 (44.0)	19 (38.0)	74 (49.3)	24.7±4.3
Trading	13 (26.0)	18 (36.0)	34 (68.0)	65 (43.3)	21.7±6.3
Planting / harvesting	9 (18.0)	12 (24.0)	24 (48.0)	45 (30.0)	15.0±4.6
Meetings	23 (46.0)	15 (30.0)	12 (24.0)	50 (33.3)	16.7±3.3
Total	126	125	143	394	-

P – value for the association between activities carried out and non peri-domestic setting = 0.000
P – value for the most reoccurring outdoor activity = 0.263
*** Statistically significant at P ≤ 0.05**

Densities of host-seeking mosquitoes indoors and outdoors

In Table 5, a total of one hundred and nine (n=109) mosquitoes were caught from the three houses sampled indoor and outdoor with CDC light traps. Of the collected mosquito species, *Culex* species comprised 46.8% of the collections; while 30.3%, 17.4% and 5.5% records were for *Anopheles*, *Mansonia* and *Aedes* species respectively. CDC light traps indoor collected 31.2% (n=46) mosquitoes while the CDC light traps outdoor collected 68.8% (n=63) mosquitoes. Of the *Anopheles* mosquitoes (n=33) collected, *An. gambiae* s. l. were more in number (n=15), followed by *An. funestus* (n=11), *An.coustani* (n=6) and *An. moucheti* (n=1). Of the *Anopheles* collected indoor using CDC light traps, *An.gambiae* s. l. were more (n=9) while, *An. funestus* were collected more (n=8) outdoors. Members of the *An. gambiae* complex were identified as *An.gambiae* s. s. using PCR. More mosquitoes (n=51) were collected were from the farm house and (n=39) Hut house than Block house (n=19). There was no significant association in the indoor and outdoor abundance of mosquitoes in the different house types (P = 0.382).

Table 5: Mosquito species collected in Nyumangbah

Mosquito species	Indoor			Outdoor			TOTAL
	Block	Hut	Farm House	Block	Hut	Farm House	
Cx.quenquefasciatus	6	9	8	5	9	14	51
An.gambiae s. s.	1	6	3	0	3	2	15
An.funestus	0	0	3	2	1	5	11
An.coustani	0	0	0	0	1	5	6
An. mouchetti	0	1	0	0	0	0	1
Mansonia uniformis	0	1	5	4	0	1	11
Mansonia africana	1	2	0	0	2	3	8
Aedes albopictus	0	0	0	2	1	1	4
Aedes aegypti	0	0	0	0	1	1	2
TOTAL	**8**	**19**	**19**	**13**	**18**	**32**	**109**

Data from Health Facility

A retrospective data from August, 2017 through September, 2018 were collected from the Primary Health Facility Ikpoikpo. From the facility record, 398 persons (163 patients ≤ 5 years old and 235 other patients above 5 years) presented with fever and were tested for *Plasmodium* with RDT kit. The overall prevalence of 66.6% (n = 265) was observed. Prevalence of *Plasmodium falciparum* infection among patients ≤ 5 years old was 52.8% (n = 86) while prevalence among participants above 5 years was 76.2% (n = 179). There was significant difference in the prevalence of *Plasmodium falciparum* infection between patients ≤ 5 years old and those above 5 years (P = 0.000). The pattern of malaria parasite infection over the months within the duration of data generation is shown in Figure 2.

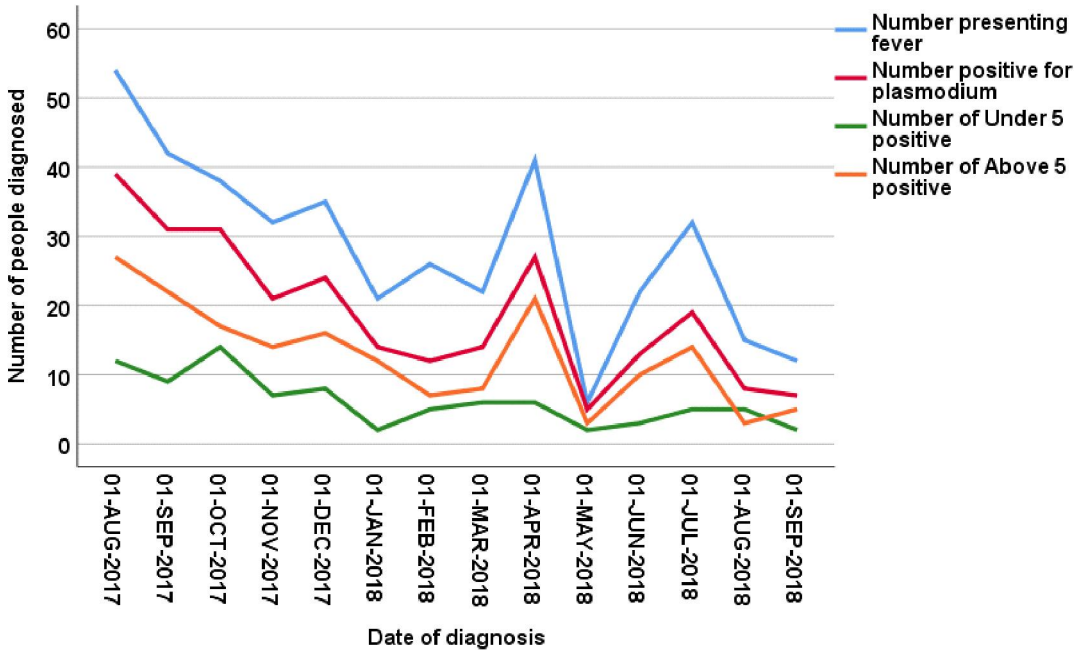

Figure 2: Health facility Data on malaria incidence in Nyumangbah from August 2017-September 2018

Discussion

Household characteristics show that inhabitants of Nyumangbah were found to either live in a block house, hut or farm house. From the study, those who live in farm houses were mostly males. It shows that the workforce involved in large scale agricultural activities in the study area are males. It equally showed that males may have higher level of exposure to mosquito bites than females since the farm houses may lack windows, good doors and good roofing. On the other hand, females were found mostly in block houses or huts. They might be the wives and female children of those males in the farm houses. In age stratification, teenagers and young adults dominated the huts and farm houses whereas individuals aged 31 years and above dominated the block house. This age stratification may simply suggest that children whose parents are actively involved in farming activities stayed with their parents in the farm houses or huts. Then adults, 31 years and above may be involved in economic activities other than agriculture in the study area. Some of them who are still active in agriculture may have realized some money with which they can build or rent a block house and also buy motor cycle for shuttling between their farm lands and their residence. Thus, they are less likely to be found in farm houses. To a very large extent, the farming population in the study area comprised those who obtained at most primary level of education. This is evident by considering the number of them that are found in farm houses. Majority of those who attained secondary level of education were able to afford living in block houses.

Irrespective of house types, this study revealed that 82% of the households own at least one LLINs while 64% of them used the net a night before the survey. LLINs have proven to be effective against endophilic vectors such as *An. gambiae s.s, An. arabiensis,* and *An. funestus* as seen in the study of Wanji *et al.,* (2003), Oyewole *et al.,* (2007) and Tuno *et al.,* (2010). This study recorded higher level of LLINs ownership than usage. Findings from Tobin-

West and Alex Hart (2011) in Rivers State, Egbuche *et al*. (2013) in Anambra State and Omonijo Adetunji and Omoniji Adejumoke (2019) in Ekiti, all observed this same pattern of more net ownership than usage as seen in this study. The 64% level of usage in this study is below the 80% national target for LLINs utilization unlike in the work of Adaji and Gabriel (2019) in the adjoining Local Government Areas with 86% net utilization. Nevertheless, households living in block houses showed the highest level of ownership and usage of LLINs as compared to those living in huts and farm houses. This may be because of their level of education as more educated people (those who attained secondary and tertiary levels of education) lived in block houses. According to Mmbando *et al*. (2009) educational status has shown to affect the ability to understand written or verbal information about symptoms, treatment, and transmission mechanisms of malaria. Also, Goesch *et al*., (2008), showed an association between educational status and health seeking behaviours in terms of protecting one's self from mosquito bite (bed net ownership and use).

From the study, it was observed that individuals living in the block houses mostly retire to their sleeping rooms around 22:00hrs as compared to those in the huts (22:30hrs) and farm houses (23:00hrs). This late hours outside houses may be due to lack of electricity, so they prefer staying outdoor for some to receive "*fresh air*" while indulging in other activities. The long stay outdoors where LLINs usage is very difficult exposes them to mosquito bites and mosquito-borne diseases, especially malaria. For instance, it was gathered from this study that individuals in the study area may experience up to three malaria episodes in a year, with an average number of two episodes mostly occurring in August and December. This agrees with the findings of Rono *et al.,* (2015) which reported that some people suffer more than one episode of malaria in the sub-Saharan Africa. The multiple malaria episodes may be as a result of reinfection due to individual and community social behavior, although there is still possibility of recrudescence and relapses from previous infections. Thus human behavioural changes alongside early diagnosis, early treatment, and use of vector control tools are required to bring a drastic reduction inmalaria incidence in Nyumagbagh as this was the same measures applied on the Thai-Myanmar border (Parker *et al.,* (2015) and Carrara *et al*.,2013).

Among several studies that have been conducted on ITNs / LLINs ownership and use, only a few of them had concentrated on identifying factors associated with usage particularly in the rural communities which are often characterized by socio-economic features that are different from that of urban communities. Predominant socio- cultural and economic activities within the community and households altering the normal sleeping pattern and making the use of insecticide treated net non-effective were identified in this study. The routine of drinking of alcohol, charging of phones, meetings, watching football matches, visiting the farms at night, selling of farm produce late into the night, burials and weddings that lasts late into the night increases the risk of exposure to mosquito bites and malaria transmissions. Similar outdoor activities were also observed in the studies of Munroe *et al.,* (2014, 2015, 2019a), Dunn *et al,* (2011) and Alaii *et al.* (2003). People staying for long periods of time taking alcohol outdoors still engage in other activities. This finding is in line with that of Monroe *et al*., (2019b) who reported that drinking alcohol was perceived to increase risk behaviour such as staying outdoors late into the night. This trend is consistent with reports in many countries seeking the elimination of malaria, where adult males who stay late outdoors drinking represent a rising proportion of malaria cases (Cotter *et al*., 2013; Jacobson *et al.,* 2017). As an agrarian community, farm produce abounds all through the year and with lack of mechanized storage facilities, the products tend to be wasted. To avoid wastage and loss, most of the community members bring their produce to sell in the markets and majority of the sellers are women with babies. Thus, selling of farm produce at the market which runs late into the night is another high impact activity with respect to potential malaria transmission in the study area.

Among the mosquito species found in the study area were: *An. gambiae* s. s.., *An. funestus, An. coustani, An. moucheti, Culex quinquefasciatus, Mansonia uniformis, Mansonia Africana, Aedes aegypti* and *Aedes albopictus*. Most of these mosquito species have been reported in Nigeria (Aju-Ameh *et al*., 2016; Egbuche *et al.,* 2016; Ezihe *et al.,* 2017; Ogola *et al.,*2018; Ezihe *et al.,* 2019; Egbuche *et al.,* 2020). Even though more mosquitoes were collected outdoors than indoors using the same technique (CDC Light trap), the difference was not statistically significant. But then, it shows that most breeding habitats of mosquitoes are found outdoors and as the mosquitoes searches for hosts, they may fly inside the house to take blood meal or rest after blood meals. Studies in Southern Nigeria by Awolola *et al.,* (2003) and Awono-Ambene *et al*., (2004) indicate that *An. gambiae* s. s seeks host outdoors.

The presence of *Anopheles* mosquitoes is an indication of malaria parasite transmission in the study area. This is evident in malaria prevalence record of 66.6% from the hospital data. Since the medical reports of the individuals in the hospital records shows that they had axillary temperature ≥ 37^{o}C, malaria prevalence of 66.6% is a confirmation that all fever are not malaria related (Oladipo *et al.,* 2015; Egbuche *et al.,* 2019). The implication of this finding is that proper diagnosis of malaria in patients with fever remains the key especially in Sub- Saharan Africa where malaria is endemic. The principal transmitter of the malaria parasite in the study area may be *An. gambiae* s. s. which had earlier been implicated by Irikannu *et al.* (2019) in Awka. *An. gambiae* s. s. as seen in this study typically exhibited both endophagic and endophilic behaviours as in the study of Gillies and De Meillion (1968) and Pappa *et al*., (2011), though some level of exophily was also observed. The pattern of biting activity by the *Anopheles* mosquitoes in the study area tended to coincide with human sleeping patterns. For instance, *An. funestus* was collected mostly outdoors as people were carrying out activities outdoors and this is in line with the studies of (Killeen *et al*., (2016). Expectations were that *An.gambiae* s.s would be collected more outdoors due to the excito-repellence activity of the insecticide (Pyrethroid) in the LLINs as opined by Reddy *et al*., (2011) but it was not so. The result in this study points that either the malaria vectors were resistant to the insecticide used for the LLINs (Dawa® net) given in year 2016 or the community members did not properly adhere to the usage. The Dawa® net distributed in the community have 50mg/m^{2} of deltamethrin (a pyrethroid) as chemical component although resistance to deltamethrin has been elucidated by Chukwuekezie *et al.,* (2020). Furthermore, Pyrethroid resistance affecting both *An. gambiae* s. s. and *An. coluzzii* has been widely reported in Nigeria (Awolola *et al.,* 2002, 2007, Okorie *et al.,* 2011, Nwankwo *et al.,* 2017 and Chukwuekezie *et al.,* 2020).

Outdoor activities in peri-domestic and non peri-domestic settings within the study area could be the reason for such high prevalence of malaria. Early biting of *Anopheles gambiae* s. l. has been seen to commence outdoors within a time range of 18:00hrs to 21:00hrs in Nigeria (Dandalo *et al.,* 2007; Atting *et al.,* 2016; PMI, 2017). From the household questionnaire, it is apparent that the earliest mean time the households retire to sleep was 22.00hrs. This is seen among those living in the block houses possibly because they power their small generators and enter indoors earlier than others, as Walch *et al*., (2016) suggested that the arrival of electric lighting in the last few decades have changed behaviors of people over time. Before then there is biting and possible transmission of malaria parasites to the individuals while they are still outdoor. Irrespective of the availability of light, people who attends burials and weddings (especially traditional marriages) and stayed out till night are still exposed to mosquito bites.

Indoor biting is not ruled out because of housing type as well as LLINs ownership and usage. The graduation of housing type in sub-Saharan Africa from traditional huts with thatched-roof to cement houses with metal-roof was thought to have profound reduction in the transmission of malaria. This is because Lindsay *et al.,* (2003) stated that poorly constructed houses allow easy entrance of *mosquito* vectors and increases chance of transmission among family members. Mosquitoes were equally distributed in the three housing types in the study area as no significant association was found between indoor and outdoor abundance of mosquitoes in and around the houses. It simply means that the housing conditions in the study area are poor and offers no protection from mosquito bites.

The farm houses surveyed were occupied by farmers and the numbers of *Anopheles* mosquitoes collected were higher than in huts and block houses. This suggests that the effect of occupation on malaria incidence can also be direct as seen in the study of Ghebreyesus *et al*., (2000). The finding in this present study like staying temporary in farm shelters has a likelihood of increasing contact of individuals with malaria vectors thereby increasing the risk of infection with *Plasmodium as t*his is in line with the findings of Saita *et al.*, (2019). Aside farm house, some respondents in this study prefer the hut houses with thatched roof as they claim the block house seem hotter than the huts thereby making the later airier to sleep in. This is corroborated by the findings of Jatta *et al*., (2018).

The burden of malaria has been known to be greater in children less than five years compared to those above five (WHO 2014), although several studies (Edelu *et al.,* 2018, Mawili Mboumba *et al.,* 2013) have found out that the trend is tilted towards significantly higher risk of malaria among subjects above five years. The age-related prevalence in this study from the health facility shows that the prevalence was higher among subjects above five years. This finding agrees with the studies of Chukwuocha *et al.,* (2012) and Raimi and Kanu (2010) who presented clearly that other age-groups also have great malaria burden. The higher positive results obtained among these age groups might be due

to their occupational and socio-cultural settings. These groups expose themselves either as a result of their work, handling school home-work and chores are more likely to be subjected to mosquito bites compared to the under-fives who mostly stay indoors. This is in agreement with Jenkins *et al*., (2015) who opined that human behavior is influenced by cultural, social and economic factors which directly or indirectly affect health outcomes, including the risk for infectious diseases like malaria.

On the monthly distribution of malaria incidence, two peaks, August and December were recorded. It might be due to infection acquired during the raining season when mosquito population abounds (Egbuche *et al*., 2020). This finding is in line with the study of Umaru *et al*., (2015) and Satoguina *et al*., (2009) in Gambia where malaria transmission occurred in the rainy seasons among children above five years.

Conclusion

This study has revealed the socio-cultural and economic activities that have high impact on malaria transmission in Nyumagbagh. The impact include: staying out late, rendering LLINs use irrelevant, exposure to mosquito bite, persistent prevalence of malaria and multiple malaria episodes in a year. It therefore becomes pertinent that complementary interventions like full protective wears, repellents and aerial fumigation for outdoor malaria vectors should be of high priority. Improvement on housing type, literacy level, occupation, electricity, knowledge about malaria and proper diagnosis of malaria for the rural dwellers will be an added assistance to the existing malaria control measures.

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