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Malaria vectors distribution, abundance and assessment of factors influencing acceptance and use of Insecticide Treated Nets in Uyo Akwa Ibom State Nigeria

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Abstract

The abundance and distribution of malaria vectors as well as compliance with the use of Insecticide Treated Nets (ITNs) are key factors in the fight against malaria. Malaria vector species composition, distribution and attitude of residents of Uyo to ITNs were studied. Weekly surveys were conducted in 2018. *Anopheles* mosquito larvae were collected from the four different axes of the metropolis, reared to adult stage and morphologically identified. Four hundred (400) structured and pre-tested questionnaires were administered to 400 respondents aged 18-70 for their knowledge and compliance with ITNs use [285 (71.25%) females and 115 (28.75%) males]. A total of 689 *Anophelines* were collected and identified, 289 (42%) males and 400 (58%) females distributed as follows: 182 (26.41%) from Idoro Road, 168 (24.38%) from Use Offot, 145 (21.04%) from Oron Road and 194 (28.15%) from Ikpa Road areas respectively. *Anopheles gambiae* s.l. made up 98 % (675) while 14 (2%) of the total collections were *Anopheles funestus* s.l. There was a significant difference in abundance of the two mosquito species in the studied areas ($p < 0.05$, (0.000); χ^2 calc=2.41, df =1). More females, 171 (60%) than males 46 (40%), used ITNs although there was no significant difference ($p > 0.05$, (0.000); $\chi^2 = 28.050$, df = 1). There was a significant difference ($\chi^2 = 48.876$, df = 1, $p = 0.000^*$) in the usage of ITNs by respondents of different ages. There was no significant difference ($\chi^2 = 1.265$, df = 2, $p = 0.531$) in ITNs use with household population. *Anopheles gambiae* s.l. were the major malaria vectors from this study. Poor awareness of the benefits of ITNs was found although many respondents knew about the nets. Public enlightenment on the use and benefits of insecticide treated nets is needed to demystify the negative perceptions of insecticides with which the nets are treated and sustain the gains of the National Malaria Elimination Program.

Keywords: Malaria, Distribution, Insecticide Treated Nets (ITNs), Mosquito

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1. Introduction

Malaria still maintains its status among the most important infectious, insect-transmitted diseases of man despite considerable research and implementation efforts (Gilles and Warrell, 1993; Talisuna et al. 2004; and WHO, 2015). The tropical and subtropical regions of the world, including much of sub-Saharan Africa, Asia and the Americas experience malaria. Significant amount of rainfall, consistently high temperatures and high humidity, along with the presence of suitable breeding sites are among the major reasons that explain why malaria abound in sub-Saharan Africa especially and less importantly, these other parts of the world (Prothero and Mansell, 1999).

Malaria is a disease of poverty and underdevelopment. It remains a complex and overwhelming health problem (Sachs and Melaney, 2002). There were 212 million cases of malaria in 2015 and 429,000 deaths (WHO, 2015). Sub-Saharan Africa is home to localities suffering from the highest global malaria transmission levels and its consequent morbidity and mortality (Hay and Snow, 2006; and WHO, 2019). The degree of malaria infection varies from region to region in Nigeria, with *Plasmodium falciparum* accounting for 90% of Nigeria's total malaria cases (Awolola et al., 2005). Repeated exposure to malaria in endemic areas lead to the development of certain degree of immunity against the parasite during the first decade of life (Brabin, 2002; McGregor et al., 2003). The impact of malaria on maternal and child health makes it an important public health concern (Orimadegun et al., 2007; WHO, 2015 and WHO, 2019).

Symptoms of malaria can be quite many, but in most cases would include fever, shivering, aches, and during worse conditions, vomiting, anaemia, haemoglobinuria, inadequate erythropoietic response of the bone marrows and convulsions may be experienced (Beare et al., 2006). Some study has also found that malaria could cause cognitive impairments especially in children (Boivin, 2002).

Female *Anopheles* mosquitoes are the agents by which malaria is transmitted to man. They carry infective sporozoites from an infected person to a non-infected person. *Anopheles* mosquitoes breed in surface water pools where environmental conditions are ideal for their development (WHO, 2005a; 2005b; and WHO, 2006). In Nigeria, about 37 different *Anopheles* species have been documented (Afolabi et al., 2006). More recent studies have identified mosquitoes of *Anopheles gambiae* (principally *Anopheles gambiae* s.s and *Anopheles arabiensis*), and *Anopheles funestus* as the main vectors of malaria in Nigeria (Sinka et al., 2010; Okwa et al., 2009; and Amadi et al., 2015). Within the *Anopheles gambiae* complex, *Anopheles arabiensis* predominates in the north and *Anopheles melas* in the mangrove coastal zone. Other localized vectors include *Anopheles nili*, *Anopheles coustani*, *Anopheles moucheti* and *Anopheles squamosus*. These species vary in their ability to transmit the *falciparum* malaria in Africa (White, 1974; Coluzzi, 1992; WHO, 2014a; 2014b; and Sinka et al., 2010). In Nigeria, malaria infection and distribution of mosquito vectors vary across the different ecological zones of the country, and could differ even among close proximities.

Proper use of ITNs is one of the major recommendations for protecting people in endemic areas against mosquito bites and malaria infection (WHO, 2015; and WHO, 2019). It has proven to be a cost-effective intervention against malaria. There are evidences of the public health impact of Insecticide Treated Nets (ITNs) which support their large-scale use in Africa as it is obtained in areas of stable malaria transmission and community disease prevalence of greater than 40% (Lengeler, 2004). Malaria control and elimination in Africa is mainly based on the use of indoor residual spray (IRS) and ITNs. The WHO recommends the use of ITNs for preventive public health programs (WHO, 2017). In an effort to ensure equality in access, the WHO advocates the free distribution of ITN coupled with effective behavioral change communication strategies to encourage people to use the nets appropriately and consistently (WHO, 2017). Several strategies have been used to increase ownership and usage of nets, as well as to reduce inequalities in ITNs ownership and usage in Nigeria. A typical strategy is the free distribution campaigns conducted by the Nigerian Federal Ministry of Health (Grabowsky et al., 2007). Over, 60 million ITNs were distributed in Nigeria between 2009 and 2013 as part of universal ITNs campaign to protect an estimated 29 million households in Nigeria (NMCP, 2014).

ITNs are designed to kill mosquitoes when they come in contact with it and pick some lethal doses of the insecticide with which the nets have been impregnated, usually the pyrethroid insecticides. They also have proven repellent properties that reduce the number of mosquitoes biting humans to near zero when properly utilized (Egbuche et al., 2013). ITNs are estimated to be twice as effective as untreated net (WHO, 2014b) and offer more than 70% protection when compared with no net usage (Bachou et al., 2016). Net ownership is not the only barrier to achieving reduction in malaria morbidity and mortality. Individuals who own nets must use them correctly in order for the potential benefit to be realized (Mala et al., 2011). The present study was

therefore designed to identify the major malaria vectors in Uyo metropolis and to assess community knowledge and usage of ITNs.

2. Materials and methods

2.1. Study area

The study was carried out in Uyo metropolis, Akwa Ibom State, Nigeria during the months of April to August, 2018. Samples were collected in four different parts of the metropolis namely: Useh Offot (Lat. 5°02'34.90" Long. 7°96'89.41"), Idoro Road (Lat. 5°05'74.50" Long. 7°88'46.82"), Oron road (Lat. 5°05'11.83" Long. 7°87'02.28") and Ikpa Road (Lat. 5°04'76.90" Long. 7°92'58.18") areas (Figure 1). Uyo is located within the tropical rainforest belt of West Africa. Two seasons exist, the rainy and dry seasons. The rainy season extends from April to October while the dry season extends from November to March. The study area is holoendemic for malaria and perennial with intense transmission throughout the year.

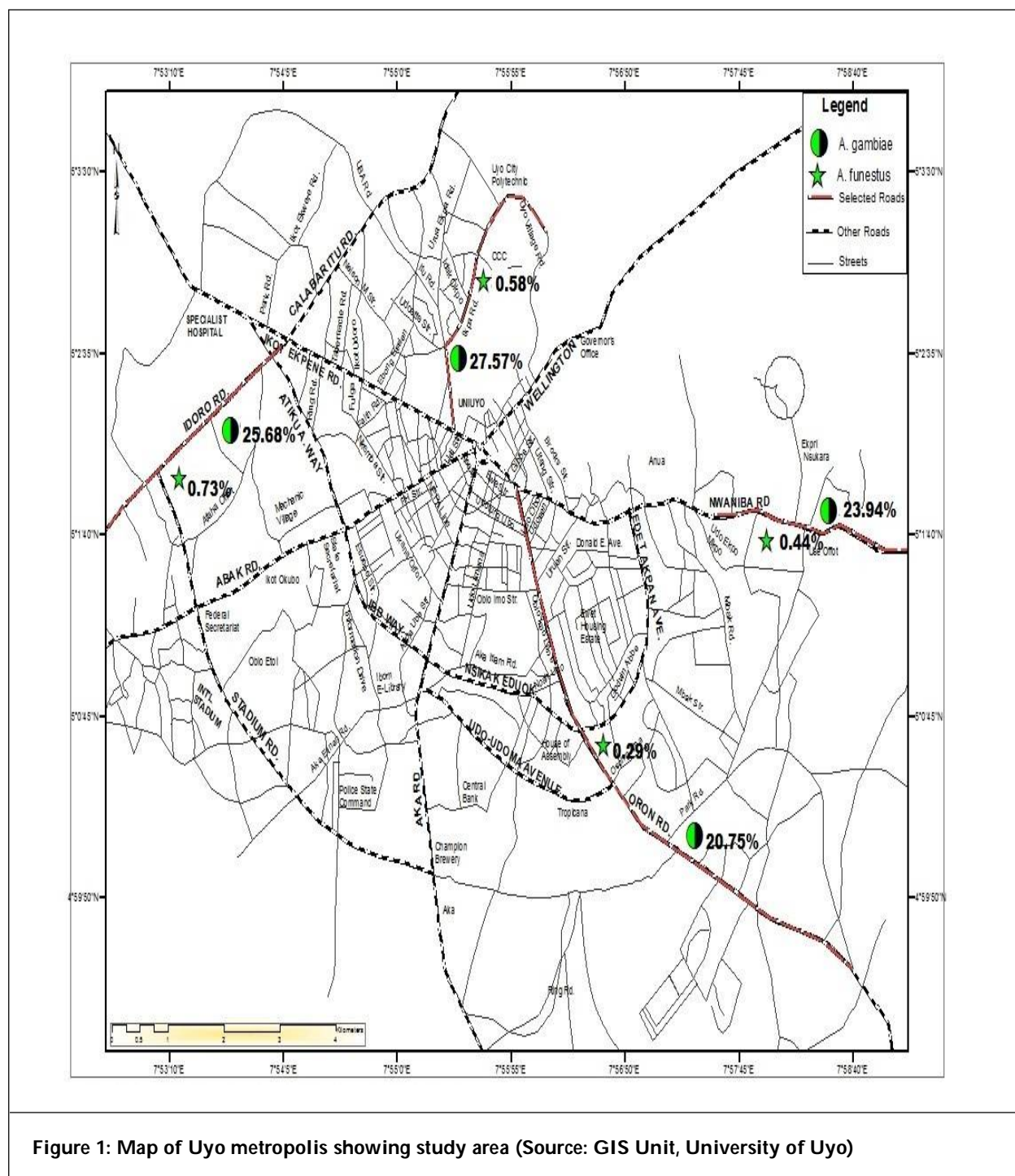


Figure 1: Map of Uyo metropolis showing study area (Source: GIS Unit, University of Uyo)

2.2. Sample collection

Weekly preliminary surveys were conducted to identify stagnant water bodies and other potential *Anopheles* mosquito breeding sites. Larval sampling was done using the standard dipping method with a 350 ml mosquito scoop (Bioquip, Gardena, CA, USA), and a white enameled dipper as described by Service (1993a and 1993b). This allowed the larvae to be seen easily. The dipper was lowered gently into the water at an angle of about 45° until one side was just below the surface, taking care not to make the larvae swim downwards. The surface of the water was skimmed with the dipper while moving along the breeding sites. Larvae were transferred into a collection bowl and transported to the laboratory.

Collected larvae were reared to adult stage in the laboratory. Emerged adults were later identified.

2.3. Morphological identification of the *Anopheles* mosquitoes

Adult *Anopheles* mosquitoes were immobilized by freezing and identified using the morphological keys of Gillies and Coetzee (1987). The identification was however not to sibling species level since we only used morphological techniques for the identification rather, to complex level.

2.4. Sample size determination

The sample size for this study was calculated using single proportion formula at 95% confidence interval (CI) level.

$$n = \frac{Z^2 \times p(1-p)}{e^2}$$

$$Z = 1.96 \text{ (at 5\%, } p < 0.05)$$

$p = 50\%$ been an expected prevalence no work on this topic has been reported in Uyo

$e =$ is error rate 0.05

$$\text{Thus: } \frac{1.96^2 \times 0.50(1-0.50)}{0.05^2} = 384.16$$

It was estimated that a sample size of at least 384 participants will be required for this study. A total of 400 were then recruited to take care of attrition and more importantly because 384 is only the minimum sample size required to make inferences on the study population (Eke et al., 2016).

2.5. Community mobilization and selection of households

Prior to the commencement of this study, a pre-mobilization team visited each of the communities with a letter of introduction from the Head, Department of Animal and Environmental Biology, Faculty of Science, University of Uyo, Nigeria. The objectives of the study were thoroughly explained to them. Community leaders were requested to assist in wide dissemination of the study information to community members.

Approximately 100 participants per community were targeted for the study and households were randomly selected using a segmented sampling interval determined from community population or number of households.

2.6. Assessment of ITNs ownership and usage

A cross-sectional survey was carried out using sampling cluster technique. Four hundred (400) structured and pre-tested questionnaires were administered to informed and consented respondents in different households. Data was collected from respondent aged 18-70 years. The survey questions focused on the sociodemographic characteristics of the respondent and their ownership and usage of insecticide treated net.

3. Data analysis

Data obtained from this study were subjected to descriptive statistical analysis. Student *t*-test was used to compare *Anopheles* mosquito species groups while chi-square test was used to determine the association that existed in the use of insecticide treated nets in the various categories of demographic characters in the four areas covered. All analysis were performed using Statistical Package for Social Sciences (SPSS) version 21.0 by IBM Cooperation.

3.1. Ethical approval

Ethical approval for this work was obtained from the Akwa Ibom State Ministry of Health Ethical Committee.

4. Results

4.1. Morphological identification of *Anopheles* mosquitoes

The different wing, leg and palp patterns of *Anopheles* mosquitoes obtained from different locations in Uyo metropolis are presented in Table 1. Of the total 698 *Anopheles* mosquitoes collected, 98% (675) were identified as members of the *An. gambiae* s.l. while 2% (14) were identified as members of the *An. funestus* s.l. There was a highly significant difference ($p \leq 0.05$) between these two *Anopheles* mosquitoes groups (Table 1).

Location	Identification parameters for <i>Anopheles</i> mosquitoes		
	AWPB (%)	AWNPB (%)	Total (%)
Use Offot area	177 (23.94)	5 (0.73)	182 (24.67)
Idoro road area	165 (25.68)	3 (0.44)	168 (26.12)
Oron road area	143 (20.75)	2 (0.29)	145 (21.04)
Ikpa road area	190 (27.57)	4 (0.58)	194 (28.15)
Total	675 (98.00)	14 (2.00)	698 (100.00)
t-test	17.461		
df	3		
p-Value	0.000*		

Note: AWPB – No. with pale band on wing, speckled legs, 3 unequal white band on the palp with the tip band as the widest; AWNPB – No. with no pale band on wing, dark legs, 3 equal white bands on the palp, * – Significant at $p \leq 0.05$.

In Use Offot, 23.94% of the anophelines had pale interruption on the third main dark area of its wing, speckled legs and three white bands with the tip band being the widest on its palp while a total of 5 (0.73%) had no pale interruption on the third main dark area of its wings, dark legs and palps with three equal bands on the palps. In the Idoro Road area, 25.68% of the anophelines had pale interruption on the third main dark area of its wing, speckled legs and three white bands with the tip band being the widest on its palp while 0.44% had no pale interruption on the third main dark area of its wings, dark legs and palps with three equal bands on the palps. Oron road area recorded 20.75% of the total anophelines with pale interruption on the third main dark area of its wing, speckled legs and three white bands with the tip band being the widest on its palp. Only about 0.29% had no pale interruption on the third main dark area of its wings, dark legs and palps with three equal bands on the palps. In Ikpa road area, 27.57% of the anophelines in had pale interruption on the third main dark area of its wing, speckled legs and three white bands with the tip band being the widest on its palp. Only 0.58% had no pale interruption on the third main dark area of its wings, dark legs and palps with three equal bands on the palps.

4.2. Distribution of *Anopheles* mosquito species in Uyo Metropolis

The results of the distribution of female *Anopheles* mosquito population obtained from different locations in Uyo metropolis are presented in Table 2. Only mosquito vectors belonging to two *Anopheles* mosquito species complexes were found in the different parts of the Uyo metropolis studied, namely: *An. gambiae* s.l. and *An. funestus* s.l.. Of these, 98% of the total *Anopheles* collected were of the *An. gambiae* s.l. while 2% were of the *An. funestus* s.l. Comparison of the abundance of *Anopheles gambiae* s.l. to *Anopheles funestus* s.l. revealed a significant difference between the two species groups ($p \leq 0.05$) (Table 2).

Location	Latitude	Longitude	NAGSL (%)	NAFSL (%)	Total (%)
Use Offot	5 02'34.90''	7 96'89.41''	177 (23.94)	5 (0.73)	182 (26.41)
Idoro Road	5 05'74.5''	7 88'46.82''	165 (25.68)	3 (0.44)	168 (24.38)
Oron Road	5 05' 11.83''	7 87'02.28''	143 (20.75)	2 (0.29)	145 (21.04)
Ikpa Road	5 04'76.9''	7 92'58.18''	190 (27.57)	4 (0.58)	194 (28.15)
Total			675 (98.00)	14 (2.00)	689 (100)
t-Test			17.461		
Df			3		
p-Value			0.000*		

Note: NAGSL – No. of *An. gambiae* s.l, NAFSL – No. of *An. funestus* s.l, * - Significant at $p \leq 0.05$.

4.3. Sociodemographic characteristics and insecticide treated nets usage

A total of 400 questionnaires were administered in the four different parts of the metropolis, with respondents ranging from 18- 70 years. Those between 18-29 years were 150 (37.5%), 30-39 were 120 (30%), 40-49 were 94 (23.5%), 50-59 were 21 (5.25%), 60 and above were 15 (3.75%). Of the total respondents, 285 (71.25%) were females while 115 (28.75%) were male. On occupation, 12% were farmers, 19.5% were traders, 15% were students, 6.25% were teachers, 2.5% were carpenters, 9.75% were tailors, 20.75% were drivers, 10.5% were hair stylist, 3.75% were electricians (Table 3).

The household population ranges from 1-15 persons with a mean of 8%. Number of persons per household between 1-5 were 135 (33.75%) followed by 6-10 with 250 (62.5%) and 11-15 were 15 (3.75%). On their educational status, 6% of the 400 respondents reported that they had not attended any school before while 39.5% manage to attend primary school, 37.5% secondary school and the remaining 17% Tertiary Institution (Table 3).

	Variable (n = 400)	Frequency (%)
Age (Year)	15-29	150 (37.5)
	30-39	120 (30.0)
	40-49	94 (23.5)
	50-59	21 (5.25)
	60 and above	15 (3.75)
Sex	Male	115 (28.75)
	Female	285 (71.25)
Household population	1-5	135 (33.75)
	6-10	250 (62.5)
	11-15	15 (3.75)
Educational status	None	24 (6.0)
	Primary	158 (39.5)
	Secondary	130 (37.5)
	Tertiary	68 (17.0)

Table 3 (Cont.)

	Variable (n = 400)	Frequency (%)
Occupation	Farmer	48 (12.0)
	Trader	78 (19.5)
	Student	60 (15.0)
	Teacher	25 (6.25)
	Carpenter	10 (2.5)
	Tailor	39 (9.75)
	Driver	83 (20.75)
	Hair stylist	42 (10.5)
	Electricians	15 (3.75)

4.4. Assessment of insecticide treated net usage

Out of 400 respondents, 99.5% agreed to knowing what ITNs are, while 0.5% do not know what insecticide treated nets are. There were 346 (86.5%) respondents who accepted having ITNs in their household while the remaining 44 (13.5%) had none. The study also showed that 79.5% of the respondents had at least one ITN in their household, 6.5% had two and above while 13.5% reportedly had none in their household. On the use of the nets, 46.25% often used the net, 8.75% once a week, 5.0% twice a week, and 40.0% never used ITNs. Only 28.75% persons used the net the previous night while 56.25% did not use the net the previous night.

Respondents had different complaints about the nets, 27.0% of them mentioned burning sensations as reason for not using ITNs, 11.5% used the net for other purposes, 8.75% used the net in the farm, 18.25% said it was stuffy and 1.0% of the respondent said they don't know how to use the nets. Some 12.5% saw no side effect while using ITNs, 8.25% reported choking breathe, 4.0% coughing, 37.25% stuffy nostrils and 38.0% complained of excessive heat associated with the nets. Comfort while using the net was found in 44.25% and 55.75% did not feel comfortable while using the net. The nets were effective in 82.25% of respondents while 17.75% refuted the effectiveness of the nets.

Relationship between demographic characteristics with reported usage of ITNs is shown in Table 4. More females (63.86%) than males (34.78%) reported household usage of at least one insecticide treated net. There was significant difference ($\chi^2 = 28.050$, $df = 1$, $p = 0.000^*$) in the usage of insecticide treated net between males and females. Respondents within the ages 21-30 (54.67%) reported higher household usage of insecticide treated net compared with those within ages 31-40 (51.67%), 41-50 (15%), 51-60 (4%). There was significant difference ($\chi^2 = 48.876$, $df = 1$, $p = 0.000^*$) in the usage of insecticide treated net by respondents according to their age groups. A significantly higher proportion of respondents with household population of 6-10 (72.8%) compared with those with household population of 1-5 (70.37%) and 11-15 (60%) reported household usage of insecticide treated net. There was no significant difference ($\chi^2 = 1.265$, $df = 2$, $p = 0.531$) in the usage of insecticide treated net within household population from 1-5 to 11-15.

5. Discussion

The vector surveillance study showed that the highest number of anophelines (194) was found in the Ikpa Road area. This may be due to the preponderance of breeding sites and a lack of environmental management of breeding sites. These environmental management practices include reduction and management of breeding sites like ponds, potholes, burrow pits, rice fields and salt marshes. These can be drained or impoundments built to achieve stable mosquito control. From the result as shown in Table 1, 98% of the total *Anopheles* collected were identified as *Anopheles gambiae* s.l. The third main dark area of its wing had pale interruption, the legs were speckled and it had three unequal white bands with the tip band being the widest on its palp. This correlated with the study carried out by Collins *et al.* (1987) and Sinka *et al.* (2010) on the identification of *Anopheles gambiae* s.l. The remaining 2% of the *Anopheles* collected were identified as *Anopheles funestus* s.l. The third main dark area of the wing had no pale interruption, the legs were dark and it had three equal white band on its palp as described by Koekemoer *et al.* (2002). *Anopheles funestus* s.l. were only found in relatively low

Table 4: Relationship between sociodemographic characteristics and insecticide treated net usage						
Factors	Use insecticide treated nets (%)	Don't use insecticide treated nets (%)	Total (%)	χ^2	df	p-Value
Sex						
Male	40 (34.78)	75 (65.22)	115 (28.80)	28.05	1	0.000*
Female	182 (63.86)	103 (36.14)	285 (71.30)			
Age range						
18-30	82 (54.67)	68 (45.33)	150 (38.50)	48.876	4	0.000*
31-40	62 (51.67)	58 (48.33)	120 (30.80)			
41-50	15 (15.95)	79 (84.50)	94 (24.10)			
51-60	4 (19.05)	17 (80.95)	21 (5.40)			
60 and above	0 (0.00)	5 (100.00)	5 (1.30)			
Household population						
1-5	95 (70.37)	40 (29.63)	135 (33.80)	1.265	2	0.531 ns
6-10	182 (72.8)	68 (27.2)	250 (62.50)			
11-15	9 (60.0)	6 (40.0)	15 (3.80)			
Note: ns – Not significant at $p > 0.05$, * – Significant at $p \leq 0.05$.						

proportion. This could be attributed to the vector survival parameters such as the abundance of suitable breeding sites, environmental conditions among others.

Of the two *Anopheles* species groups found to be responsible for the transmission of malaria in Uyo metropolis, *Anopheles gambiae s.l.* predominated across the study sites. This is consistent with the report of Awolola (2017) that the main malaria vector in Africa is the *Anopheles gambiae s.l.* Coluzzi et al. (2002) also reported that the most important vector of malaria parasite in sub-Saharan Africa is *Anopheles gambiae s.l.* which exhibits extreme heterogeneity. Again, this finding agrees with the work of Ekpo et al. (2018) which revealed that 100% of the mosquito populations across breeding sites in Eastern Obolo, Akwa Ibom State were of the *Anopheles gambiae s.l.* Although, this study agrees with published studies, more work needs to be done in order to be able to emphatically say the mosquito vector composition of the study areas as the present work was for a shorter period of time and utilized morphological characters only for the identification of species.

Current WHO initiative in malaria control such as roll back malaria programme (RBM) emphasizes the use of insecticide treated net as one of the key strategies for malaria prevention and control, but even especially so in sub-Saharan Africa (Jones, 2002). Knowledge of insecticide treated net in this study was found to be very high (99.5%) because people believed they were old enough to be an insecticide treated net owner and accepted a free net because they were offered, rather than because they planned to use it or thought that they needed it. As a result, they would pay attention to advocacy and sensitization messages and information regarding the nets during net campaigns. However, the willingness to use the nets was not maintained, as only 46.25% were found to be willing to use it.

The reduced willingness to use the nets was observed despite the fact that nets were distributed free in intense campaigns and sensitizations. This finding agrees with the studies of Thwing et al. (2008) in Niger Republic. It was noted that insecticide treated net given free during bed net distribution campaigns were used for protecting the 'nursery' (waterleaf and small crops) from birds. These correspond well with a similar reported misuse of bed nets in Kenya by Minakawa et al. (2008). Although, Baume and Marin (2007) reported

that nets distributed free were less used than net purchased, no respondents attached its free distribution as a reason for less use.

Free delivery of ITNs had been shown not to necessarily increase ITN usage. Some studies have shown that a personal decision to purchase a net may motivate one to use the ITNs (Baume and Franca-Koh, 2011) rather than getting it for free. Therefore, the suggestion by Sexton (2011) is reiterated here; there seems to be a need for commercial distribution of ITNs but at a subsidized rate. This may further improve ITNs utilization. Such a strategy, backed by education on the proper care and maintenance of the nets to ensure their durability, is also likely to lay the foundation for a sustained supply of ITNs.

The main reason for non-use of insecticide treated net by the respondents is the excessive heat associated with the net (33.5%). Other reasons attributed to the non-use of insecticide treated net include: burning sensation (27%), not knowing how to use them (1%) and nets being stuffy (18.25%). This agrees with findings of Nuwaha (2002) where low bed net utilization was reported by 74% respondents and the reason was discomfort because of heat/humidity. Greater malaria knowledge, education and wealth are not consistent determinants of net use (Eisele et al., 2009).

6. Conclusion

The results of this study have shown that the two major *Anopheles* species groups in the studied areas were *Anopheles gambiae s.l* and *Anopheles funestus s.l*. The knowledge of ITNs although abundant, did not improve usage. Many were afraid of the chemical insecticides used in treating the nets, heat associated with its usage, amongst many other issues. This information will assist the malaria control/elimination authorities in planning and implementing appropriate strategies for dealing with malaria and its vectors. It will also encourage further advanced studies to know which particular species of *An. gambiae s.l* and *An. funestus* complex is actually present. Health promotion packages debunking the negative perceptions on the chemicals used in treating the nets would be a great boost to the acceptability and use of the nets since people base their concern on perceived side effect of the chemical insecticides used in treating the nets.

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