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Insecticide-Treated Bed-Nets Ownership, Utilization and Potency on *Anopheles* Population from Gombe, North East, Nigeria

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ABSTRACT

Malaria vector control relies principally on the use of chemical-based control strategies of Long Lasting Insecticides Nets (LLINs) and Indoor Residual Spray (IRS) at the community level. This study aimed at evaluating insecticide-treated bed-nets ownership, utilization and potency against *Anopheles* populations from Akko and Kaltungo Local Government Areas (LGAs) of Gombe State, Nigeria. The study was carried out in eight (8) communities of the LGAs between the months of January and December, 2022. A well-structured questionnaire containing 24 items was administered in each of the communities for insecticide-treated bed-net ownership and utilization and two bed-nets were sampled to determine potency. The immature *Anopheles* mosquitoes were collected from breeding sites using the standard dipper and reared to adulthood in the laboratory. All the tests were conducted at the temperature of 25-33˚C and relative humidity of 60-80%. The bio-assayed females were identified morphologically using dichotomous key of Coetzee. The results showed high bed-net ownership (98.9%) and Insecticide-Treated Nets utilization (93.8%) among the respondents' households. Despite the high rate of bed-nets ownership the level of utilization was still below 100% recommendation of World Health Organization. Moreover, DuraNet (98%), Olyset-plus (100%) PermaNet 3.0(98%) showed optimal effectiveness while Netprotect (3%) with minimal effectiveness. In conclusion, high bed net ownership and utilization among residential households was established with efficacy on *Anopheles* after long term usage. Therefore, more awareness campaign is recommended in the study area to achieve maximum control and elimination of malaria vectors.

Keywords: ITNs, Ownership, Utilization, Potency, Malaria

INTRODUCTION

Malaria is widely spread in Nigeria with 97% of the population is at risk of malaria infection (US PMI, 2020). Globally, Nigeria has the highest burden of malaria (27%) cases and 31% mortality (WHO, 2022) contributing about more than one-fourth of the world malaria burden. Approximately 50% of the Nigerian population experience at least one episode per year. It is a leading cause of disability, illness and death usually to under five (5) aged children and slow economic growth to productive age persons (Soumaila *et al.,* 2022). According to NMIS (2021), malaria prevalence among children age 6-59 month tested positive using microscopy fell by 22% from 42% in 2010 and Gombe State

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was having 18% malaria prevalence which as second behind Bauchi State with 32% in North east, Nigeria.

Vector controls are important strategies in the reduction of disease transmission. Currently, mosquito vector control relies on the use of long-lasting insecticide-treated mosquito nets at the national level and pockets of IRS in some rural communities. WHO has recommended universal coverage of ITNs particularly Long Lasting Insecticidal Treated Nets (LLINs and Indoor Residual Spray IRS as core interventions in malaria-endemic countries to reduce global malaria burden in 2030 by 90% globally (Federal Ministry of Health, 2015). In Sub-Saharan Africa 590 million ITNs were delivered to communities between 2019-2021 and the percentage of households with at least one ITNs for sleeping increases by 5 % from the previous years (World Malaria Report, 2021). Likewise, the percentage population sleeping under ITNs increases considerably from 4% in 2000 to 47% in 2021 (WHO, 2021). Approximately, 84% of ITNs were delivered to sub-Saharan Africa in which 68% of households at least owned one ITN for sleeping in 2019 (World Malaria Report, 1997, 2020). World malaria report has shown that 55% of households in Nigeria possess at least one mosquito net for sleeping and 48% of these are in the urban area (Alawode *et al.,* 2019). Recently, there was increase to 56% of households in Nigeria own at least one ITNs in 2021 which was decreased from 69% in 2015. Rural communities' ownership of ITNs was reported to be higher (58%) than urban areas (53%) (NMIS, 2021) which is below the recommendation of 80% ownership and 100% utilization by the World Health Organization (WHO). A number of studies have reported that sleeping under LLINs can reduce vector-human contact thereby protecting humans against mosquito bites. This has led to 40% reduction in malaria cases after 15 years of ITNs distribution campaigns globally (WHO, 2018), incidence of malaria cases by 50%, severe malaria by 45% and malaria mortality in children by 55% (Linn *et al.,* 2019).

In spite of the LLINs distribution and pocket IRS ongoing, since 2009, yet the highest (27%) global malaria burden occurs in Nigeria (WHO, 2020). Accordingly, malaria remains a major public health concern in Gombe with average prevalence of 92% among pregnant women attending primary health care (Yoriyo and Hafsat, 2014; Sarki *et al.,* 2019). This is worsened by low percentage ownership (60%) and utilization (55%) of ITNs (Muhammad and Naphthali, 2014) regardless of the ITNs distribution campaign. The studies on ITNs have focused on pregnant women and children under-five year old in urban and rural settlement/communities of Nigeria (Biadgilign *et al.,* 2012; Angesom *et al.,* 2020; Onyebueke *et al.,* 2021) neglecting the other age groups which are also at risk of malaria infection.

In recent years the successes of these control tools have been endangered by the emergence and increase of insecticide resistance of major malaria mosquito vectors. The regular use of pyrethroids for impregnation of bed-nets for vector control programmes had positively impacted as transmission blocking measure but the development of resistance have been recorded in certain parts of the world including Nigeria (Awolola *et al.,* 2009; Oduala *et al.,* 2012, 2019; Ibrahim *et al.,* 2019; WHO, 2022; Kayode *et al.,* 2023,). The present research is of utmost importance in the assessment of ownership and utilization of ITNs toward the prevention and control of malaria in Gombe State. The multiple insecticides resistance and their impacts on LLINs distribution campaigns for policies formulation will be established.

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MATERIALS AND METHODS

Study Area

Akko LGA has its headquarters in Kumo on the Yola-Jalingo highway South of the capital city of Gombe State. It lies between latitude 09° 54' 24.1" and 09° 54'24.1"N and Longitude 11° 08' 31.29" and 11° 09' 44.63". The LGA covers a total land area of 2, 627 Km^2 with a projected population of 1, 081, 129.6 from 2006 census at annual growth rate of 3.2 percent. It is the largest LGA in Nigeria in term of land area. Akko LGA has an estimated humidity of 30% and average temperature estimate of 30°C while the dry season begins from November to April and raining season from May to October. It populace engage in agriculture farming activities and few are business oriented. Akko LGA sampling communities include: Ajiya quarters: 10.152312°N and 11.114179°E; Kalshingi: 10.103902°N and 11.248228°E; Jauro Bakari: 10.144859°N and 11.135512°E; Zagaina: 10.191044°N and 11.105690°E.

Kaltungo, the headquarters of Kaltungo LGA has a population of 149,805 as at the 2006 Census of the LGA's Population of 19452. The town lies between latitude 09° 48'51"and 09°81'41" N and longitude 11°18'32" and 11°30'88" E and has a land mass of 881 Km^2. Kaltungo is located at the Southern Gombe within the Sudan savannah (Fig 2). Seventy five (75) kilometres away from Gombe metropolis, Gombe State along Yola-Jalingo highway road and is just an hour's drive from Gombe the State capital. Its annual average temperature may reach 30°C and most of the dwellers are farmers. It has a distinct rainy season that spans the period June/July to September/October, and dry season between October/November and May/June. It is essentially a subsistent agricultural community, although considerable animal husbandry and trading are also undertaken. Several man-made ponds created by construction work and a poor drainage system provide favourable breeding sites for mosquitoes that transmit malaria among other diseases. Record from hospital indicated moderate cases of malaria (49.2%) and death (56.3%) among under five aged children in this area (Lomogo and Yoriyo, 2013). Four (4) sampling communities were randomly selected and their coordinate are as follows; (Lakolin: 9.831042°N and 11.338485°E; Lapandintai: 9.822407°N and 11.331450°E; Popondi: 9.471161°N and 11.312323°E; Sabon Layi: 9.816280°N and 11.311228°E).

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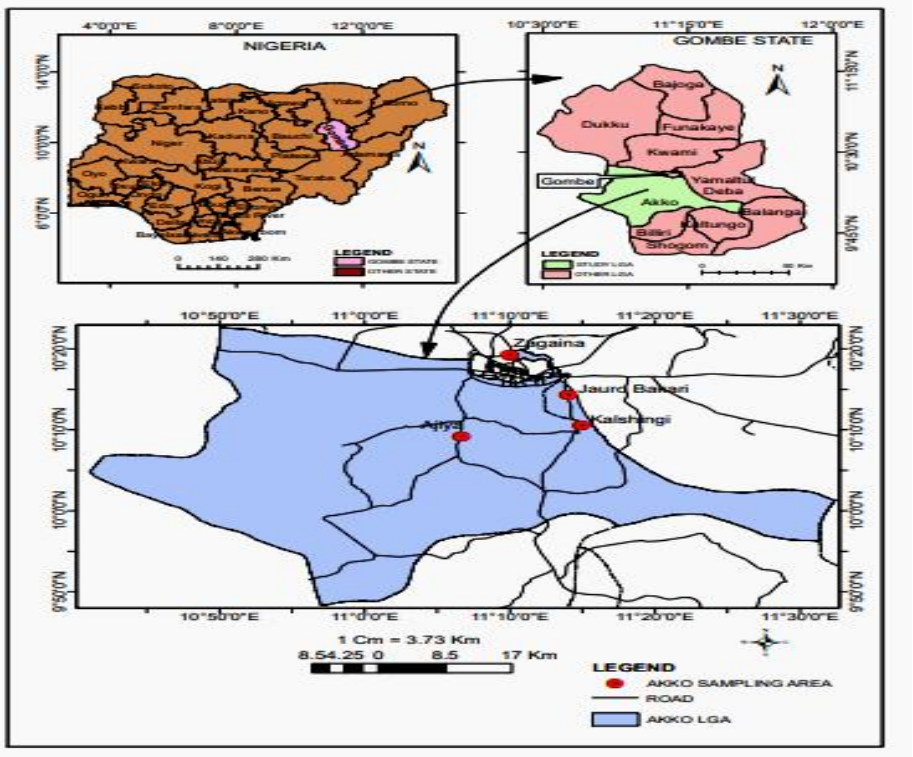

Figure1: Map of Akko LGA sampling communities (Source: ZASTAL Kashere)

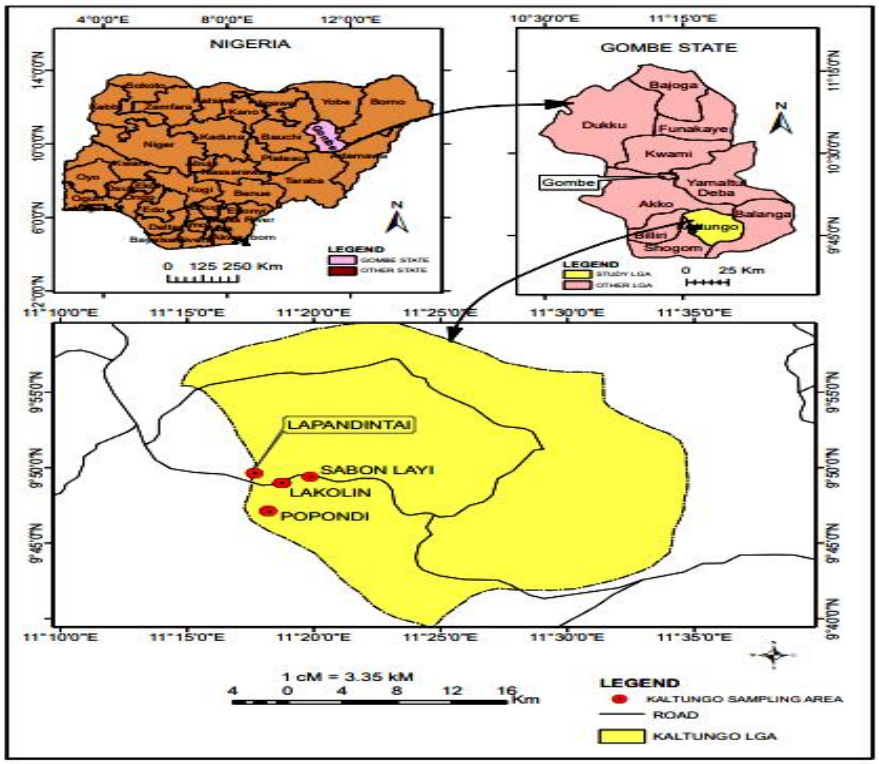

Figure 2: Map of Kaltungo LGA sampling communities (Source: ZASTAL Kashere)

DOI: 10.56892/bima.v7i4.552

Ethical Considerations and Consent to Participate

No ethical clearance was required for this study. However, the consent of the community leaders was sought in the study communities via advocacy visit. In addition, consent of the households was sought for prior to the administration of structured questionnaire and the selected of some households for bed-net efficacy testing. All information collected were kept confidential and use only for the purpose of this research. Data management was performed in agreement with the 1964 Declarations of Helsinki during World Medical Assembly (WMA) Finland.

Sampling of Household and Used ITNs

Ten (10) randomly selected houses per each community within the two LGAs (Akko and Kaltungo) were sampled for the administration of eighty (80) structure interviewed questionnaire. Ten (10) questionnaire per each community was administered to assess ITNs ownership and utilization. Additionally, a total of sixteen (16) used ITNs were collected at random and replaced with new ITNs from all the communities for determination of ITNs potency using WHO cone bioassay. Two (2) ITNs from each ten households was used for the potency bioassay.

Administration of Structure Interviewed Questionnaire

A structured questionnaire was designed based on a malaria-metric survey of literature reviewed. The interview was conducted on a face-face household-basis with the identified head of household. Where the head of the household was unavailable; interview was conducted with the representative of the household head. Only respondents between the ages of 10 and 70 years were recruited for the survey as recommended (Cavanati *et al.,* 2021). The questionnaire was developed to collect information on demographic data, socio-economic characteristics, ITNs ownership and utilization of bed-net. Field Assistants were trained to administer the questionnaire together with the researcher to collect respondents' information.

Sampling and processing of used ITNs

For each sampled ITNs, 30 cm by 30 cm was cut from standard positions 1, 2, 3, 4 and 5 (one roof and four sides). A replicate from each section was cut per ITNs. Netting samples were labeled with the net identification number, cutting position and stored in a cool dry place at 4 °C until needed. WHO standard guide for field testing of mosquito net was followed and carried out in two (2) randomly selected bed-nets in each sampled community as described in WHO (2022) guideline for mosquito testing using cone bioassay.

ITNs bioassay against *Anopheles* Mosquitoes

To determine the effectiveness of bed-nets deployed in the study area, a standard cone bioassay was employed according to WHO (2022) procedure using 2-5 days old unfed blood adult female *Anopheles* emerged from larvae collected from the eight study communities in the laboratory. A replicate of two pieces from each sites of the bed net were made and five (5) mosquitoes at a time were aspirated and introduce into two WHO cone bioassay kits (10 mosquitoes). Sixty (60) mosquitoes were exposed per bed-nets samples and untreated control bed-net for 3 minutes. All test mosquitoes were then transferred immediately to paper cups and provided with 10% glucose for 24 hours post-exposure. If the control mortality exceeded 10% the test was repeated. The knock-down effects was recorded 60 minutes post-

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exposure (KD_{60}) and final mortality after 24 hours was recorded (WHO, 2022).

Data Analyses

The proportion of ITNs achieved optimal KD_{60} ≥95% or 24hour mortality ≥80% and minimal KD_{60} ≥ 75% or 24 hours mortality ≥80 % by cone bioassay was analyzed. All data obtained from the questionnaire and laboratory tests was analyzed using descriptive statistics and categorical variables were computed using Chi-square analysis to determine associations. Significance was regarded at $\rho<0.05$.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of the Study Population

A total of 80 households participated in this study with a response rate of 100%. Majority (48, 60%) of the respondents were males, in which 54(67.5%) can read and write. Likewise, the age range of 21-30 years accounted for 25(31.2%) of the respondent and played a role as household head 37(46.2%). Business men registered 31 (38.8%) responses and had attended secondary level of education 30 (37.7) (Table 1).

Table 1: Socio-demographic characteristics of respondent in all the eight communities of study LGAs

Variables	Frequency (%)	χ^2 value	P- Value	CI (Lower-Upper limit)
Gender				
Male	48(60)	3.200[a]	0.74	0.091-0.102
Female	32(40)			
Position/Role in the house				
Head/Father	37(46.2)	6.925[b]	0.31	0.028-0.034
Mother	25(31.2)			
Children	18(22.5)			
Age				
1-10	0(0)	18.125[c]	0.001	0.001-0.002
11-20	8(10)			
21-30	25(31.2)			
31-40	19(23.8)			
41-50	6(7.5)			
51-above	22(27.5)			
Literacy level				
Can read and write	54(67.5)	9.800[a]	0.002	0.001-0.003
Cannot read and write	26(32.5)			
Level of Education				
Primary	9(11.2)	11.100[d]	0.011	0.100-0.014
Secondary	30(37.5)			
Tertiary	21(26.2)			
Non- formal	20(25.1)			
Occupation				
Public servant	13(16.2)	32.200[e]	0.000	0.000-0.000
Business	31(38.8)			
Farmer	14(17.5)			
Artisan	9(11.2)			
House wife	8(10.1)			
Not specify	5(6.2)			

**X^2 value with the same superscript are not significantly different at $p<0.05$

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Insecticide-treated Bed Net (ITNs) Ownership and Utilization

Household ownership for at least one bed-net for sleeping in the study houses was found to be 79 (98.8; 95% CI 0.000–0.000%). Thirty-two 32 (40%) and 31 (38.8%) households owned 1-2 and 3-5 bed-nets respectively (Table 2). Majority of the bed-nets were obtained from the mass net campaign (68, 85%) for free. Twenty-five households 25(31.2%) and 28(35%) reported to have obtained their ITNs 7–12 months and 19–24 months, respectively prior to the time of data collection. Thirty-four 34 (42.5; 95% CI 0.000–0.000%) and 32 (40%) of the respondent households uses at least 1-2 and 3-5 bed nets, respectively. Forty-five 45(56.2%) of the households utilized bed-net in both dry and raining season with the majority sleep 75 (93.8%) under the bed net between 6-10 pm (61, 76.2%). Table 3b indicates that majority of the respondent wash their net whenever is dirty 44 (55%) with Omo® 48(60%) and shade-dried (50, 62.5%).

Table 2: Mosquito net ownership among respondents in all the study sites

Variables	Frequency (%)	χ^2 value	P- Value	95% CI(Lower-Upper limit)
Do you have a bet-net in your house?		76.050[a]	0.000	0.000-0.000
Yes	79(98.8)			
No	1 (1.2)			
How many bed-nets do you have?		28.500[d]	0.000	0.000-0.000
1-2	32(40)			
3-5	31(38.8)			
6-8	13(16.2)			
9-11	4(5)			
How many bed-nets do you use?		62.375[c]	0.000	0.000-0.000
Never use	1(1.2)			
1-2	34(42.5)			
3-5	32(40)			
6-8	9(11.2)			
9-11	4(5)			
When do you use your bed-net		79.375[c]	0.000	0.000-0.000
Never use	2(2.5)			
Raining season	14(17.5)			
Dry season	1(1.2)			
Whenever there is mosquito	18(22.5)			
Always	45(56.2)			
What is the age of the bed-net?		44.950[e]	0.000	0.000-0.000
0-6 months	12 (15)			
7-12 months	25(31.2)			
13-18 months	3(3.8)			
19-24 months	28(35.0)			
25-36 months	10(12.5)			
Don't know	2(2.5)			

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Table 3a: Mosquito bed-net utilization among respondents in all the study sites

Variables	Frequency (%)	χ^2 value	P-Value	
Do you use bed-net for sleeping?		61.250[a]	0.000	0.000-0.000
Yes	75(93.8)			
No	5(6.2)			
If no what do you used it for?				
Window screen	1(1.2)			
Door screen	0(0)			
Fishing	0(0)			
None of the above	79 (98.8)			
What time of the night do you sleep inside bed-net?		113.800[d]	0.000	0.000-0.000
6-10 pm	61(76.2)			
11-2 am	11(13.8)			
3-6 am	0(0)			
Whenever mosquito make noise	3(3.8)			
Always	5(6.2)			
How often do you sleep inside the bed-net		211.625[c]	0.000	0.000-0.000
Daily	68(85)			
Once every year	2(2.5)			
When I see mosquito	5(6.2)			
Never	2(2.5)			
Not specify	3(3.8)			

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Table 3b: Mosquito bed net utilization among respondents in all the study sites

Variables	Frequency (%)	χ^2 value	P- value	95% CI (lower-Upper)
Sources of mosquito bed-nets				
Mass-net Campaign		158.700[d]		0.000-0.000
	68(85)		0.000	
Hospital	5(6.2)			
Market	4(5)			
Don't know	3(3.8)			
Has it been washed?		48.050[a]	0.000	0.000-0.000
Yes	71 (88.8)			
No	9(11.2)			
How often do you wash your bed net?		65.500[c]	0.000	0.000-0.000
Monthly	6(7.5)			
Quarterly	16(20)			
Once every year	6(7.5)			
Whenever is dirty	44(55)			
Never wash	8(10)			
What type of detergent do you wash the net				
Omo	48(60)	95.875[c]	0.000	0.000-0.000
Soap	21(26.2)			
Bleach	1(1.2)			
Water only	2(2.5)			
Not specify	8(10)			
Where was the net dried after last wash?		45.325[b]	0.000	0.000-0.000
Sun	29(36.2)			
Shade	50(62.5)			
Other specify(roof)	1(1.2)			

Susceptibility status to used brands of Bed-net

High mortality (98%) was recorded for insecticide concentration of 4.0 g/kg roof, 2.1g/kg side + 25g/kg deltamethrin+ PBO impregnated PermaNet 3.0 nets. PermaNet 2.0 and DuraNet recorded mortality of 96% each at chemical concentration of 55 mg/m^2 permethrin and 261 mg/m^2 ± 25% α-cypermethrin respectively. MagNet recorded 92% mortality at 261mg/m^2 ± 25% α-cypermethrin. The Cone bioassay of used bed-nets revealed that, PermaNet 3.0 registered a highest mean mortality of *Anopheles* followed by PermaNet 2.0/ DuraNet and Magnet respectively. At holding time of 60 minutes, higher knockdown were recorded by Olyset plus$^+$ 100% followed by DuraNet 98% and 96% PermaNet 3.0 respectively. This implies that Olyset plus$^+$ at concentration of permethrin 2% w/w, 800 mg/m^2 plus PBO 1% w/w, 400mg/m^2 had high knock down rate (Figure 3).

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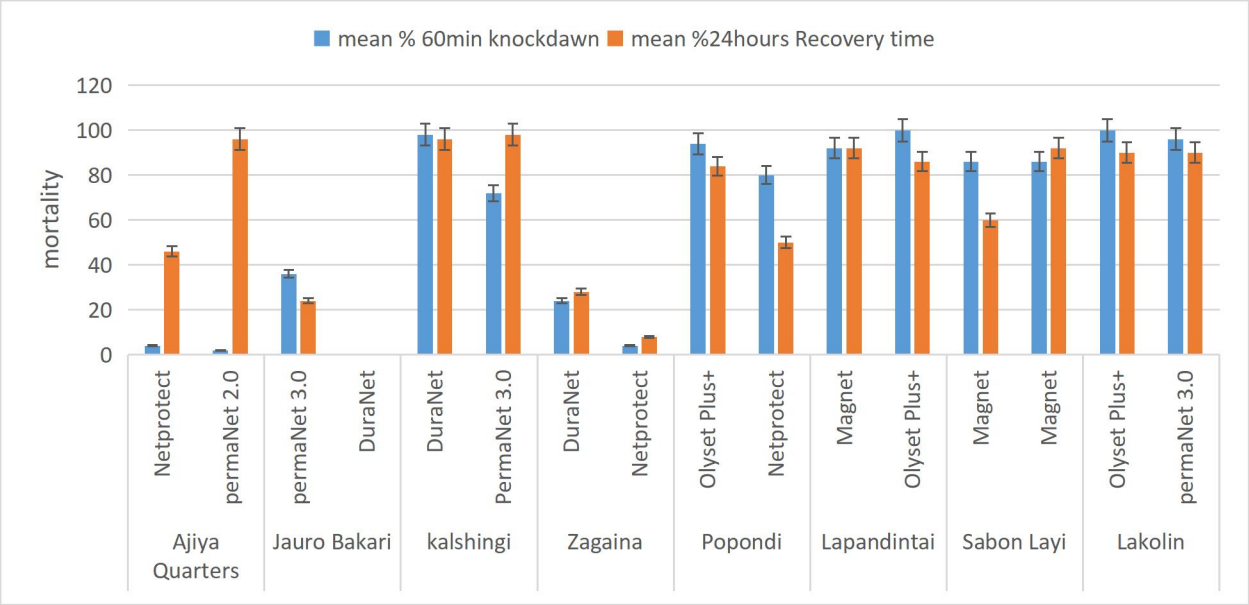

Figure 3: Mean percentage knockdown and mortality of *Anopheles* mosquitoes from the eight communities after 60 min holding period and 24 hours recovery time exposed to six (6) different brand of used mosquito nets.

DISCUSSION

Findings of this study revealed that majority of the respondents were males with high percentage of those who can read and write. Contrary to our finding female respondent is high 73.7% and majority 68.1% were illiterate in Ethiopia (Biadgilign *et al*., 2012) .

The ownership of bed-nets for sleeping among the residential household registered was above the WHO recommendation of 80% ownership (WHO, 2012). Our finding contradicts the finding of NMIS, 2021 reported 82% household in Gombe owned at least one ITN for sleeping and 85% ITNs ownership in Yobe (Ali *et al.,* 2020). Previously, Eteng *et al*. (2014) reported 87% of ITNs ownership for sleeping during 2010 and 2011 mass bed net distribution campaign in Bauchi. A five years review studies of 59 article conducted among pregnant women and under five age children in Sub-saharan Africa in 2012 demonstrated 80% bed-net ownership and the determinant factors are educational level, knowledge of malaria, socio-economic status, community involvement and parity (Sigh, Brown and Rogesson, 2013). Similarly, the result from this study established an increase from the previous finding of 55% in all the States of Nigeria (Alawode *et al*., 2019), and 72% among household in River, Southern part of Nigeria (Odoko *et al*., 2020). Likewise, in sub-Saharan Africa, 68% of the household owns ITN in 2019 (WHO, 2020). Biadgilign *et al*. (2012) recorded 62.4% in Ethiopia while 87.1% was reported among women aged 25-34 years old in Southern Nigeria (Onyebueke *et al*., 2021). Recently, 56% of households in Nigeria own at least one ITN in 2021 which was a decrease from 69% in 2015. Rural communities' ownership of ITNs was reported to be higher 58% than urban areas (53%) (NMIS, 2021). Although, ownership of mosquito net is above the WHO recommendation in Gombe which might be the reason for the reduction of malaria prevalence 18% among under five aged children (NMIS, 2021) compared to the whole country Nigeria having the highest global malaria burden of 27% (WHO, 2022). Aweis

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et al. (2023) recorded about 80 % of pregnant women and 22. 5% of children age less than 59 month uses LLINs for protection against mosquito bite and malaria prevention in Magadishu, Somalia. The researcher further stated that, LLINs coverage and ownership does not grantee reduction in hospital attendance and death due to malaria but effective utilization couple with ownership will yield a desire results. Majority (68, 85%) of the nets were obtained from the mass net distribution campaign for free which has been ongoing since 201I in Gombe. The mass distribution campaign of ITNs to malaria endemic countries have been reported to be the main reason for the reduction of 40% of global malaria cases (WHO, 2018) compared to 22% in African region (World Malaria Report, 2019) and 55% reduction of malaria mortality in children globally (Linn *et al*., 2019).

The finding from our study recorded high percentage of 93.8% net usage among residential household in study locations which is higher than the previous studies of 55% among pregnant women attending antenatal clinic in Gombe LGA (Mohammed and Napthali, 2014), 35% in Yobe (Ali *et al.,* 2020), 40.68% utilization in Calabar metropolis (Komomo *et al.,* 2016) and 60% in Sub-Saharan Africa among pregnant women (Sigh, Brown and Rogesson, 2013). Correspondingly, 80% ITN utilization has been established in Rivers, Southern Nigeria (Odoko *et al.,* 2020). However, the researcher and program manager in malaria policy making are of the opinion that, mass distribution of LLINs coverage and ownership had good level of success in Nigeria but utilization is still below expectation (Omo-Imafidon *et al*., 2022). The high ITNs usage in the study area is attributed to mass awareness campaign via mass media and town announcers as well as advocacy visit to village leaders during the distribution campaign. It was also established that prevalence of malaria reduces post ITNs distribution and utilization(Ali *et al.,* 2020). Our finding is contrary to the report by WHO 2021 establishing 47% individual of all age group sleeping under ITNs globally and Angesom *et al.* (2020), observed lower utilization among pregnant women in Ethopia. The low utilization of ITNs is associated with family size, place of residence and malaria history. Majority of the respondent washed their net whenever it is dirty with Omo and shade dry. This could affect the efficacy of the bed net and durability. In contrast, WHO has suggested that ITNs should be washed 20 times under standard laboratory with mild Soap in order to sustain it efficacy for three years protection against mosquito bite.

Our finding on the potency of used mosquito bed-net deduce that, DuraNet, Olyset plus^{+}, PermaNet 3.0 has optimal effectiveness while Netprotect and MagNet had a minimal effectiveness similar to WHO (2022) report on the insecticide susceptibility of bed-net indicating PBO net are more effective than non-PBO net although; low effectiveness has been reported in Tanzania compared to Dual-AI net having two different insecticides with different mode of action (Zahouli *et al.,* 2023). In a separate study, Mugenzi *et al.* (2022) and Tchouakui *et al.* (2022) observed similar pattern of bed net potency against *An. gambiae* s.l. in Southern Ghana and Uganda respectively with PBO PermaNet 3.0 shows 100% mortality while DuraNet, MagNet and Olyset plus^{+} exhibit low optimal effectiveness using cone assay. The optimal efficacy observed in this study is likely connected with exo-repellant effect and high knock dawn ability of PBO-based bed nets as compared to non PBO-based bed Nets.

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CONCLUSION

It was established that, 98.8% of the Household own at least one mosquito net and 93.8% used the net for sleeping. DuraNet (98%), Olyset plus^{+} (100%) PermaNet 3.0(98%) had optimal effectiveness while Netprotect (4%) had a minimal effectiveness and no mortality was observed with DuraNet in Jauro Bakari. Following WHO criteria we could deduce that, DuraNet, Olyset plus^{+}, PermaNet 3.0 had optimal effectiveness while Netprotect has a minimal effectiveness although DuraNet had no mortality in Jauro Bakari there was variation in effectiveness of the used bed-net between one community and another.

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REFERENCES

Alawode, O. A., Chima, V. and Awoleye, A. F. (2019). Household characteristics as determinants of ownership of mosquito nets in urban households in Nigeria. *Scientific African*, 6.

Ali, A., Bala, A. Y., Okwuonu, E. S., Orakwelu, C. H., and Aguzie, I. O. (2020). Reduction of malaria by insecticide-treated mosquito nets in Potiskum, Yobe State, Nigeria. *International Journal of Tropical Disease and Health*, *December*, 1–10.

Angesom, T., Gebreyesus, H., and Gebremariam, B. (2020). Long-lasting insecticidal net utilization and associated factors among pregnant women in Asgede Tsimbla District, Northern Ethiopia, (2017). *Environmental Health Insights*, *14*.

Aweis, A., Salad, A. A., Araye, F. A., Ahmed, A. M., Wehlie, O. A., Osman, A. A., andAkuku, I. G. (2023). Long-lasting insecticidal nets (LLINs) use among household members for protection against mosquito bite in Mogadishu districts. *PLOS Global Public Health*, 3(3), e0000724.

Awolola, T. S., Oduola, O. A., Strode, C., Koekemoer, L. L., Brooke, B., andRanson, H. (2009). Evidence of multiple pyrethroid resistance mechanisms in the malaria vector *Anopheles gambiae* sensu stricto from Nigeria. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 103(11), 1139–1145.

Biadgilign, S., Reda, A. and Kedir, H. (2012). Determinants of ownership and utilization of insecticide-treated bed nets for malaria control in Eastern Ethiopia. *Journal of Tropical Medicine*, June 2014.

Canavati, S. E., Kelly, G. C., Vo, T. H., Tran, L. K., Ngo, T. D., Tran, D. T., Edgel, K.A., Martin, N. J. (2021). Mosquito net ownership, utilization, and preferences among mobile and migrant populations sleeping in forests and farms in Central Vietnam: a Cross-sectional study. *The American Journal of Tropical Medicine and Hygiene,* 104(5), 1917-1924.

Eteng, M., Mitchell, S., Garba, L., Ana, O., Liman, M., Cockroft, A. and Andersson, N. (2014). Socio-economic determinants of ownership and use of treated bed nets in Nigeria: Results from a cross-sectional study in Cross River and Bauchi State in 2011. *Malaria Journal,* 13:316.

Federal Ministry of Health. (2015). National Malaria Strategic Plan 2021–2025. *National Malaria Elimination Programme*, May 2015, 113. https://nmcp.gov.ng/

DOI: 10.56892/bima.v7i4.552

Ibrahim, S. S., Fadel, A. N., Tchouakui, M., Terence, E., Wondji, M. J., Tchoupo, M., Kérah- Hinzoumbé, C., Wanji, S., andWondji, C. S. (2019). High insecticide resistance in the major malaria vector Anopheles coluzzii in Chad Republic. *Infectious Diseases of Poverty*, 8(1).

Kayode, F. I., Taiwo, I. E., Adeogun, A. O., Olalekan, O., Chimdalu, I. P., Olayilola, O. I., Amos, O. T., Lynda, N. C., Adetoro, O. O., Oladosu, Y., and Adetoro, O. O. (2023). Low frequency of knockdown resistance mutation (L1014F) and the efficacy of PBO synergist in multiple insecticide-resistant populations of *Anopheles gambiae* in Ikorodu, Lagos State, Nigeria. *African Health Sciences*, 23(1), 255–261.

Komomo, E.A., Egena, R., Irene, C., Ayorinde, A.O. and Agada, P.O. (2016). Assessment of the Utilization of Insecticide Treated nets (ITNs) in Calabar Metropolis, Cross River State, Nigeria. *Journal of Health, Medicine and Nursing,* 26:196-205

Linn, S. Y., Maung, T. M., Tripathy, J. P., Shewade, H. D., Linn, Z. and Thi, A. (2019). Barriers in distribution, ownership, and utilization of insecticide-treated mosquito nets among migrant population in Myanmar, 2016: A mixed-methods study. *Malaria Journal*, 18(1): 1–16.

Lamogo Y and Yoriyo K.P. (2013). A Retrospective Survey of Malaria Prevalence in Under-five Age group. A Case Study of Kaltungo General Hospital Gombe State, Nigeria. *Journal of Medical and Biological Sciences,* Vol. 3 (2).

Mugenzi, L. M. J., Akosah- Brempong, G., Tchouakui, M., Menze, B. D., Tekoh, T. A., Tchoupo, M., Nkemngo, F. N., Wondji, M. J., Nwaefuna, E. K., Osae, M. and Wondji, C. S. (2022). Escalating pyrethroid resistance in two major malaria vectors *Anopheles funestus* and *Anopheles gambiae* (s.l.) in Atatam, Southern Ghana. *BMC Infectious Diseases,* 22:799.

Muhammad I, Naphtali RS. (2014). Investigation on the distribution, utilization, and effectiveness of ITNs in relation to malaria prevalence in Gombe LGA, Gombe State, Nigeria. *International Journal of Advanced Studies in Engineering and Scientific Invention*, 1(1): 11-18pp.

Nigeria Malaria Indicator Survey, (2021). National Malaria Control Programme, ICF International: Nigeria malaria indicator survey 2021. NPC, NMCP, ICF International, Abuja, Nigeria.

Odoko, J. O., Nwose, E. U., Nwajei, S. D., Agege, E. A., Moyegbone, J. E., andIgumbor, E. O. (2020). Epidemiology of malaria as it relates to utilization of insecticide treated nets among pregnant women and under five years children in South-South Nigeria. *International Journal Of Community Medicine And Public Health*, 7(10), 4157.

Oduola, A. O., Abba, E. Adelaja, O., Ande, A. T., Yoriyo, K. P., Awolola, T. S.(2019). Widespread report of multiple insecticide resistance in *Anopheles gambiae* s.l. mosquitoes in eight communities in Southern Gombe, North-Eastern Nigeria. *Journal of Arthropod-Borne Diseases,* 13(1): 50–61.

Oduola, A. O., Idowu, E. T., Oyebola, M. K., Adeogun, A. O., Olojede, J. B., Otubanjo, O. A. and Awolola, T. S. (2012).

DOI: 10.56892/bima.v7i4.552

Evidence of carbamate resistance in urban populations of *Anopheles gambiae* s.s. mosquitoes resistant to DDT and deltamethrin insecticides in Lagos, South-Western Nigeria. *Parasites and Vectors*, 5(1): 1.

Omo-Imafidon, E. S., Adeogun, A. O., Babalola, A. S., Okefu, P. O., andAkinyemi, O. O. (2022). Towards improvement in malaria policy implementation in Nigeria: A qualitative study on factors influencing the translation of malaria policies to practice. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 116(10):910–916.

Onyebueke, A. C., Umeobieri, A. K., and Irikannu, K. C. (2021). Awareness, ownership and utilization of insecticide treated nets against malaria vectors among pregnant women attending antenatal clinics in Awka metropolis, Anambra State, Nigeria. *International Journal of Tropical Disease and Health*, *May*, 22–31.

Sarki, A., Pukuma, M. S., Yoriyo, K. P., Kunihya, I. Z., Hafizu, M. S., Kolawole, A. A., Haruna, M. Y., Ali, R. (2019). Study on malaria infection in pregnant women attending primary health care centers in Gombe metropolis, Gombe State, Northeast, Nigeria. *Federal University DutseMa Journal of Sciences* (FJS), 3 (4): 90–97.

Singh, M., Brown, G., Rogerson, S.J. (2013). Ownership and use of insecticide-treated nets during pregnancy in sub-Saharan Africa: A review. *Malaria Journal,* 12 (268).

Soumaila, H., Hamani, B., Arzika, I.I., Soumana, A., Daouda, A., Daouda, F.A., Iro, S.M., Gouro, S., Zaman- Allah, M.S., Mahamadou, I., Kadri, I., Salé, M.N., Hounkanrin, W.,Awolola, T.S., Flatley, C. and Chabi, J. (2022). Countrywide insecticide resistance monitoringand first report of the presence of the L1014S Knockdown resistance in Niger, West Africa. *Malaria Journal*, 21:385.

Tchouakui, M., Oruni, A., Assatse, T., Manyaka, CR., Tchoupo, M., Kayondo, J., Wondji, C.S. (2022). Fitness cost of target-site and metabolic resistance to pyrethroids drives restoration of susceptibility in a highly resistant *Anopheles gambiae* population from Uganda. *PLoS ONE,* 17(7): e0271347.

US President's Malaria Initiative. Nigeria malaria operational plan FY 2020. USAID. 2020. Retrievedfromhttps://www.pmi.gov/docs/default-source/default-document-library/malaria-operational/plans/fy-2020/fy

WHO (2012). WHO Global Malaria Programme. Global Plan for Insecticide Resistance Management in Malaria Vectors [Internet]. Geneva: World Health Organization; Available at: http//: www. who. Int/malaria/vector_control/gpirm_ executive_ summary_en. pdf?ua =1.

World Malaria Report 2018. (2018). Geneva: World Health Organization; 2018. p. 32–59. https://www.who.int/malaria/publications/world-malaria-report-2018/en/. Accessed 11 Mar 2020.

World Malaria Report (2019). In *WHO Regional Office for Africa*. https://www.who.int/news-room/fact-sheets/detail/malaria

World Health Organization. *World Malaria Report. 2020.* Geneva: World Health Organization; 2020. Available from:

DOI: 10.56892/bima.v7i4.552

https://www.who.int/teams/global-malaria- programme/reports/world-malaria-report-2020

World Health Organization (2021). Word Malaria Report 2021. In *Word Malaria report Geneva: World Health Organization.(2021). Licence: CC BY-NC-SA 3.0 IGO*. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021

World Health Organization (2021). World malaria report 2021 [Internet]. In *World Health Organization*. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021

World Health Organization (2022). Guidelines for malaria. Geneva: World Health Organization; 2022. https://www.who.int/publications/i/item/ guidelines for malaria. *World Health Organization*.

Yoriyo, K.P. and Hafsat, J.B. (2014). Prevalence of Malaria Infection among Pregnant Womenattending antenatal clinic in Gombe State, *International Journal on Entrepreneurial Development Education and Science Research,* 2(1):214-220.

Zahouli, J. Z. B., Edi, C. A. V., Yao, L. A., Lisro, E. G., Adou, M., Koné, I., Small, G., Sternberg, E. D., and Koudou, B. G. (2023). Small-scale field evaluation of PermaNet® Dual (a long-lasting net coated with a mixture of chlorfenapyr and deltamethrin) against pyrethroid-resistant *Anopheles gambiae* mosquitoes from Tiassalé, Côte d'Ivoire. *Malaria Journal*, 22(1), 1–20.