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INSECTICIDES TREATED NETS (ITNS) USAGE INTENSITY AND SELF-REPORTED MALARIA PREVALENCE AMONG RURAL HOUSEHOLDS IN OSUN STATE, NIGERIA.

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ABSTRACT

This study examined the insecticides treated nets (ITNs) usage intensity and self-reported malaria prevalence among rural households in Osun State, Nigeria. A three-stage sampling technique was used to select 595 households from 6 rural LGAs. A structured questionnaire was used to collect data. Descriptive statistics, Tobit and Ordinary Least Square (OLS) regression models were employed to analyse the data. 67.6% of the households have under-6 children, 36.3% have at least a pregnant woman, 71.8% have no ITNs while 8.4%, 10.1% and 8.1% have 3, 4 and 5 household members, respectively sleeping under ITNs. Tobit estimates revealed that ITNs usage intensity was significantly influenced by sex of household heads (β=-0.1666; $p<0.01$), mother's years of schooling (β=0.0132; $p<0.1$), number of pregnant women (β=0.1110; $p<0.01$), number of ITNs in the house (β=0.1448; $p<0.01$), number of people sleeping under ITNs (β=0.1713; $p<0.01$), electricity (β=-0.1366; $p<0.05$), electric fan (β=0.1202; $p<0.1$) and households percapita expenditure (β=-1.39e-06; $p<0.01$). OLS estimates revealed that prevalence of self-reported malaria was significantly influenced by sex of household head (β=3.6534; $p<0.01$), distance to water source (β=4.6119; $p<0.01$), numbers sleeping under ITNs (β=-0.9339; $p<0.01$), environment neatness (β=-0.7307; $p<0.1$), distance to irrigation/open water body (β=-0.1625; $p<0.01$), water source (β=-0.8359; $p<0.05$) and ITNs usage intensity (β=-5.0294; $p<0.05$). This study concluded that the use of ITNs reduces the prevalence of malaria but households with at least an ITNs and usage intensity were abysmally low, hence the need to intensify efforts at extending access to affordable and effective ITNs as an efficient means of malaria control.

Key words: ITNs usage, Self-reported malaria, Tobit model, Mosquito. Rural households

INTRODUCTION

Malaria is one of the most prevalent infectious diseases which comes as a result of attacks on red blood cells by protozoa parasites belonging to genus *Plasmodium*. The protozoa get introduced into the human body through female anopheles mosquito. Human beings are infected majorly by *Plasmodium falciparum* (WHO, 2009). Malaria early symptoms are imprecise and comparable with the symptoms of other feverish diseases. The symptoms include fever, chills, vomiting, headache, fatigue, muscle and joints pain, abdominal discomfort, anorexia, perspiration and lassitude. The African region continues to be mostly affected by malaria where the continent bore almost 95% of the cases and 96% of deaths globally in 2021. In Africa, an estimated 10,000 women and 200,000 infants die yearly due to malaria complications (ISGlobal, 2019). In 2017, Nigeria was rated among the five countries that were responsible for almost half of the global malaria cases (WHO, 2019). In 2021, the global calculation of malaria cases reached 247 million, compared to 245 million in 2020 and 232 million in 2019.

Vector control has been identified as an important preventive strategy for malaria and in order to prevent and control malaria, fortunes have been committed to different initiatives and strategies by international bodies. Such preventive programmes included the promotion of the use of insecticide-treated mosquito nets (SFH, 2019). Between 2011 and 2019, more than 24 million nets were distributed free of charge in the country (USAID, 2019). Mosquito nets form protective barricades against infected mosquitoes, thereby drastically reduce transmission of malaria. ITNs are proved to be two-fold as efficient as ordinary or untreated nets and provide more than 70% protection when compared with no net (Raghavendra *et al.*, 2011). Adekanye *et al.* (2020) reported that access to ITNs reduces workdays lost to presumptive malaria among food crops farming households in rural south west Nigeria. Regrettably, Miller *et al.* (2007) reported that only 13% of families in African have insecticide treated nets despite its effectiveness in preventing malaria. Also, there is a difference between having access to mosquito nets and the actual usage compliance which this study had examined.

Malaria remains a major public health burden, particularly in rural agrarian communities where livelihoods depend heavily on human labour. The interaction between malaria incidence, preventive measures such as insecticide-treated mosquito nets (ITNs), and agricultural productivity forms a critical development issue. Malaria reduces labour efficiency, while preventive interventions like ITNs can significantly improve health and economic outcomes (Mabe and Dafurika, 2020). Study from Nigeria shows that malaria significantly reduces the productivity of arable crop farmers and increases both direct and indirect costs of farming (Ogunniyi *et al.,* 2015, Adekanye 2019). Similarly, studies in Ghana found that malaria reduces the number of days farmers spend on their farms, thereby lowering output levels (Mabe and Dafurika, 2020).

Sleeping under an insecticide treated net (ITNs) is the most commonly adopted preventive measure against malaria and it is regarded as the major defense in most malaria-endemic countries. As part of efforts to check malaria parasites and ensure that people are protected against malaria in the country, Nigerian government had distributed 193.5 million insecticide-treated nets since the commencement of free distribution of mosquito nets in 2009 (Ayinla, 2021). In 2020, more insecticide treated bednets (ITNs) were reportedly distributed than in any year on record even with the distributed ITNs still below 60% of the budgeted quantities (WHO, 2022). Shockingly, WHO (2021) stated that the universal burden of malaria has not really different over 20 years, after more than US$30 billion has been exhausted on malaria control activities including distributing more than 2.5 billion insecticide-treated bednets. Consequently, if ITNs is considered as the leading defense in most malaria endemic countries, and large sum of fund in dollars have been expended on its free distribution worldwide, then there is need to investigate the extent of usage of ITNs by the households who claimed to possess the bednets, along with the impact of the use of mosquito nets on the prevalence of the disease.

However, there is paucity of studies on the intensity of ITNs usage and its impact on malaria prevalence in Nigeria, especially among the rural households, which informed this study as an attempt to bridge the gap. The study did not rely on the access to mosquito nets alone but how many household members are actually sleeping under mosquito nets? Hence, the use of Tobit model which captured the differentials in the ITNs usage intensity among the households unlike the Logit or Probit models which will only capture access or no access to ITNs.

The study was therefore carried out to:

i. profile the respondent households' socio-demographic characteristics;
ii. profile and investigate the mosquito nets usage intensity and its determinants in the study area; and
iii. examine the influence of mosquito nets usage intensity on the prevalence of self-reported malaria in the study area.

Theoretical Framework

Laxmi *et al.* (2022) incorporated "Evolutionary game theory into a disease transmission model and came up with a Game-Theory model" which is well fitted as a theoretical framework for this study. This decision-making framework was defined as a game where the pay-off to each individual is determined by the individual's strategy and the average behavioural strategy used by the population as a whole.

Let X_h ($0 \leq X_h \leq 1$) be the proportion of the population who adopt *strategy 1* i.e the use of ITNs properly to protect themselves from mosquito bites. Then, the remaining $1-X_h$ use ITNs for other purposes perceiving to be more beneficial (*strategy 2*). As the individual choice of usage depends on the current disease prevalence, the players of the current generation not only play with each other but against players from previous generations with identical behaviours. In such strategic decision-making and social interaction, we assume that individuals emulate others activities. Specifically, they sample other members randomly at a constant rate, and if the pay-off of the sampled person is higher, then the sampled strategy is adopted with a probability that is proportional to the expected gain in pay-off (Bhattacharyya and Bauch, 2010; Bauch, 2005). It is assumed that individual switch between the two strategies depending on the perceived benefits either from using ITNs properly or improperly.

In game theory, individuals act rationally in choosing the strategy that results in a higher pay-off. After an individual has access to an ITN, the individual selects the most preferred strategy that maximizes the associated expected utility. This adaptive behaviour is influenced by several social and economic factors.

Let L Ɛ (0, ∞) denote the baseline daily productivity of an individual. Then improper use of ITNs, e.g. for fishing or agriculture may increase baseline daily productivity.

Let $r_L>1$ be the proportional increment in the daily productivity, then the perceived pay-off for improper ITN use is given by:

$$f_{im} = L(r_L + 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

By contrast, proper use of ITNs reduces the risk of infection through mosquito bites and depends on the proportions of current disease prevalence (I_h) and mosquito density (N_V) in community. if r_i is the risk of infection, then the expected pay-off for proper use of ITNs is given by:

$$F_P = r_i [1-b_\beta(t)](w_1 I_h + w_2 N_V) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where w_1 and w_2 are proportionality constants. It should be noted that the perceived pay-off is also a function of ITN efficacy since individuals are aware of the efficacy of ITNs from the onset. Thus, pay-off gain for switching to the strategy of proper use of ITNs is given by $\Delta G=f_p-f_{im}$ and accordingly, the evolution equation of X_h (when $\Delta G > 0$) is given by:

$$\dot{x}h = \epsilon x_h (1-x_h).\ \varsigma\Delta G$$
$$= kx_h\ (1-x_h)\ \{-r + [1-b_\beta\ (t)]\ (w_1I_h+w_2N_V)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where $k= \epsilon\varsigma r_i$ is the scaled emulation or imitation rate, and $r=L(r_L+1)\ /r_i$ denotes the relative profit of improper usage of ITNs.

This equation is similar to the replicator equation in population game (Hofbauer and Sigmund, 1998). It should be noted that fraction of individuals ($1-x_h$) who embark on the improper ITN use satisfies the same equation 3.

MATERIALS AND METHODS

Study area: This study was carried out in Osun State, Nigeria. The State, with a population of about 5.2 million people have Osogbo as the Capital with other major towns such as Ile-Ife, Ilesa, Iwo, Ede, Ila-Orangun, Ikirun, Ejigbo, Oyan among others. There are 30 Local Governments Areas and 1 Area Council in the State. There exist orthodox, alternative and traditional healthcare systems in the State. The State is a landlock located along forest zones of southern Nigeria with hot weather and moist which supports the abundant breeding of mosquito vectors (Babalola *et al.,* 2009). Malaria transmission is holo-endemic in the area (Ogunlesi *et al.,* 2005; Olugbade *et al.,* 2012) and Nigeria Demographic and Health Survey (2018) reported that South West in which Osun State falls, remain the zone with the lowest number of households with at least one ITN or LLIN in Nigeria. However, the State government over the years is partnering with federal government, both local and international donor agencies on health care interventions including the periodic free distribution of Insecticides Treated Nets (ITNs).

Sampling Method

This is a descriptive cross-sectional study among rural households in Osun State. A three-stage sampling technique was adopted. The first stage was the random selection of 2 LGAs from each of the three (3) Agricultural Development zones in the State, making a total of six (6) LGAs. In the second stage, five villages/rural communities were randomly selected from each of the six (6) selected LGAs, making a total of thirty (30) villages/rural communities. The third stage was the random selection of twenty (20) households from each of the selected 30 villages/rural communities. In all, a total of 600 households were selected for the study. The head of each households or his/her representative were interviewed and data collection period was about 9 weeks.

Sources and method of data collection

Primary data used for the study were collected with the aid of a self-administered structured questionnaire. Data sought include socio-demographic characteristics of the respondents, issues bordering on their health, awareness of mosquito nets usage, access to mosquito nets, extent of usage at households' level, etc. Information from household heads who were permanent resident or present in the house in the night preceding the survey were obtained.

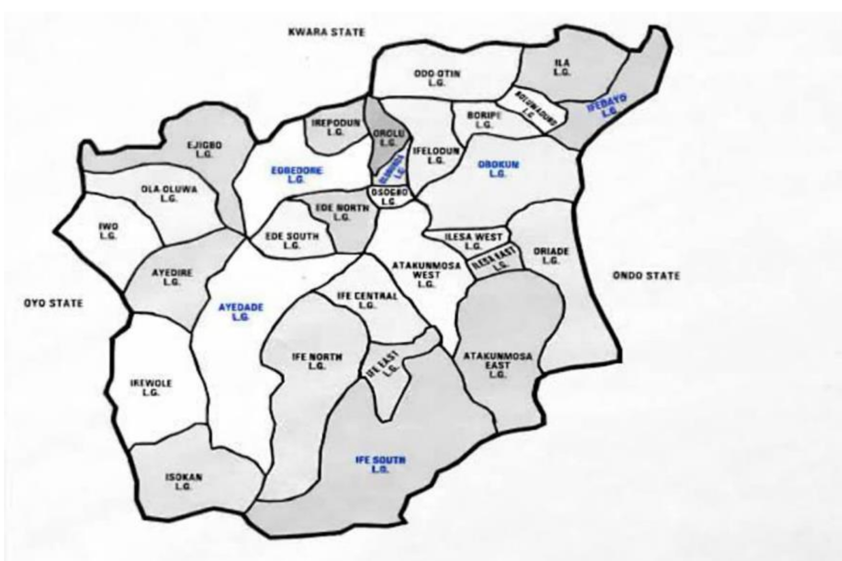

Figure 1: Map of Osun State showing the study areas in blue colour

Number of household members who slept under mosquito nets were captured to estimate the mosquito net usage intensity. Also, the number of malaria episodes reported by each household within the study period were used to estimate the malaria prevalence in the study area.

Method of Data Analysis

Various statistical models were employed to analyze the data collected. Descriptive statistics was used to analyze the socio-demographic characteristics (i.e. age, sex, marital status, education and household size; etc.) of the respondents as well as their possession and actual usage of mosquito nets. Tobit regression model was used to investigate the determinants of ITNs usage intensity while the Ordinary Least Square (OLS) regression model was employed to investigate the influences of ITNs usage intensity and other variables on the prevalence of self-reported malaria among the households

Models Specification

Determinants of ITNs usage

Tobit regression model, a hybrid of the discrete and continuous models was used to estimate the effect of some explanatory variables on the ITNs usage intensity. The Tobit model is an econometric biometric model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable y_i and an independent variable (or vector) x_i. The choice of the model as against the probit or logit models is based on the fact that there are differentials in the intensity of ITNs usage. The model is as expressed below:

$$ITNsU_i = \beta_0 + \beta_i X_i + \mu_i \quad \ldots\ldots(4)$$

$$ITNsU_i = ITNsU_i^* \quad \text{if } \beta_0 + \beta_i X_i + \mu_i > 0 \quad \ldots\ldots(5)$$

$$= 0 \text{ if } \beta_0 + \beta_i X_i + \mu_i \leq 0$$

Where:

$ITNsU_i^*$ = the latent variable and the solution to utility maximization problem of intensity of ITNs use subjected to a set of constraints per household and conditional on being above certain limit.

$ITNsU_i$ = ITNs use intensity for ith rural households (i.e the number of people sleeping under ITNs over the total number of people making up the household)

Xi = vector of factors affecting ITNs use intensity

βi = vector of unknown parameters

μi = error term

The independent variables specified as determinants of ITNs usage intensity are defined below:

X_1= sex of household head

X_2= household size (in number)

X_3= Years of schooling of household head (in years)

X_4= Years of schooling of mother (in years), if she is not the household head

X_5 = number of children below 6 years in the house (in number)

X_6 = number of pregnant woman/women in the house (in number)

X_7 = number of aged above 60 years in the house (in number)

X_8= Access to free ITNs (1 if have access; 0=otherwise)

X_9= Number of ITNs in the house (in number)

X_{10}= Number of household members who slept under ITNs in the night preceding the survey

X_{11}= Household health insurance Status (enrolled =1; 0=not enrolled)

X_{12}= Sleeping room density. (household size to number of sleeping room in the house)

X_{13}= Presence of electricity in the house: (yes=1, 0=otherwise)

X_{14}= Presence of electric fans in the sleeping rooms: (yes=1, 0=otherwise)

X_{15}=Distance to irrigation or open canal, water body e.g lake, dam, fish pond etc. (Km)

X_{16}=Distance to the nearest health centre in km

X_{17}=Household attended malaria awareness campaign in the area before. (1=yes, 0= if otherwise)

X_{18}=Household per capita monthly expenditure

Determinants of malaria prevalence in the study area (OLS)

In analysing the influences of ITNs usage intensity on the prevalence of self-reported malaria among rural households in the study area, the usual Ordinary Least Square (OLS) regression model was employed since all the respondent households reported numbers of malaria episodes during the period under study.

Following Ilahi and Grimad (2000), Ruskaneen (2004) and Babalola *et al*. (2009) etc. the OLS regression model was of the form specified below:

$$Y_i = \alpha + \beta_i X_i + \varepsilon \quad \ldots\ldots(6)$$

Y= The number of malaria episodes per household in 2024

X_i =Independent variables (malaria risk factors)

ε = error term

Explicitly;

$Y_i = f(X_1, X_2, X_4, ..., X_{25}, \varepsilon)$ ………………………………………………………….(7)

Where:
Y_i= Number of malaria episodes by ith household household in 2024
X_1=Sex of household head (1 if male; 0= if female)
X_2=Age of household head (in years)
X_3=Years of schooling of household head (in years)
X_4= Household size (in number)
X_5 =Number of children below 6 years in the house (in number)
X_6 =Number of pregnant woman / women in the house (in number)
X_7 =Number of aged above 60 years in the house (in number)
X_8= Access to free ITNs (1 if have access; 0=otherwise)
X_9= Number of ITNs in the house (in number)
X_{10}=Household health insurance Status (1 if enrolled; 0=not enrolled
X_{11}=Distance to the nearest health centre in km
X_{12}=Nature of accommodation: Housing type (Good=1, 0=Bad / Poor)
X_{13}=Status of Compound. 1=Bushy and Dirty, 0=Clean and Not Bushy
X_{14}=Sleeping room density (Household size to Number of Sleeping room in the house)
X_{15}=Presence of electricity in the house: (yes=1, 0=otherwise)
X_{16}=Presence of electric fans in the sleeping rooms: (yes=1, 0=otherwise)
X_{17}=Distance to source of water for domestic use
X_{18}=Distance to irrigation or open water body e.g canal, lake, dam, fish pond, etc. (Km)
X_{19}=Source of drinking water (1=improved; 0=non-improved)
X_{20}=Household house main floor (cemented 1; 0=otherwise)
X_{21}=Roof materials (thatch=1; iron sheet)
X_{22}=Wall condition (plastered =1; non-plastered =0)
X_{23}=House ceiling (Asbestos =1; 0= if otherwise)
X_{24}=Household per capita monthly expenditure
X_{25}=intensity of mosquito usage by the household

Ethical consideration
Participation in this study was voluntary and consent was sought from the respondents before filling the questionnaire. Ethical approval to conduct the study was obtained from the Osun State Ministry of Health, Osogbo, Health Research Ethics Committee.

RESULTS AND DISCUSSION
Socio-demographic characteristics of the respondents
Data from a total of 595 rural households were used in this analysis; the heads of rural households were mostly male (90.8%) which implies that males still maintained the headship of farming households in line with the tradition and culture of people in the study area. Opaluwa *et al.* (2022) in the study conducted among maize farmers in Idah Local Government Area, Kogi State, Nigeria had earlier reported that large proportion (77.5%) of the farm households heads were males. The age distribution of households' heads revealed that the average age was 55.7±10.2 years while the modal age class was 60-69 years. It implies that higher percentage of them are getting old and this has negative implication for productivity and tolerance to malaria attacks. Hence, the need to embrace the use of insecticides treated nets to prevent mosquito bites. The finding is consistent with Adekanye (2019) who reported that the average age of rural farming households' heads in southwest Nigeria was 56.41±9.34 years. The mean years of education was 6.6±5.3 years with 29.2% of the heads of households had no formal education while only 9.4% had tertiary education. It implies that illiteracy level among the heads of rural households is high. This is consistent with Nzelu *et al*. (2025) who reported 35.6% has having no formal education among reproductive-age women in Nigeria.

Also, nearly all (99%) of the rural farming household heads were married which is an indication that the farmers had children and possibly pregnant women that mostly vulnerable to malaria attacks if exposed to mosquito bite. Hence, the needs to adopt mosquito nets usage to prevent mosquito bites. Opaluwa *et al.* (2022) had earlier reported that 72.5% of the respondents households heads in his study area were married. Likewise, the study revealed that average household size of the rural households was 7±2 persons while the modal class of household size was 5-7 persons (62.7%). The household size is fairly large due to the peasantry nature of the rural areas in which household members supply family labour for the farms, hence the need for them to be healthy.

It was also revealed from the table 1 that 63.7% of the households do not have pregnant women during the survey whereas 29.1% and 7.2% of the households had 1 and 2 pregnant women, respectively. Pregnant women are more vulnerable to malaria due to physiological changes in their body system. Hence, the need for pregnant women to sleep under mosquito nets to prevent mosquito bites. CSLAC (2012) reported that malaria alone is responsible for about 11,000 maternal deaths, 250 infant mortality, 390 under-5 deaths, in every 100,000 live births.

Table 1: Socio-demographic characteristics of the respondents (n=595)

Sex	Frequency	Percentage of total	Mean
Male	540	90.8	
Female	55	9.24	
Age category (years)			
Less than 30	2	0.3	
30-39	40	6.7	
40-49	127	21.3	55.7±10.2
50-59	174	29.2	
60-69	201	33.8	
70 and above	51	8.6	
Education status / years of schooling			
No formal education (0)	174	29.2	
Primary (6)	175	29.4	
Modern school/ JSS certificate (9)	21	3.5	6.6±5.3
Secondary (12)	169	28.4	
Tertiary (Above 12 years)	56	9.4	
Marital status			
Married	589	99.0	
Single / widow / divorcee	6	1.0	
Household size			
Up to 4	48	8.1	
5-7	373	62.7	7±2
8-10	138	23.2	
11 and above	36	6.0	
Distribution of pregnant women in the households			
None (0)	379	63.7	
One (1)	173	29.1	
Two (2)	43	7.2	
Three and above	0	0	

Source: Field survey, 2025.

Demographic distribution of households' members

The demographic distributions of the households' members as indicated in the table 2 below revealed that 193 (32.4%) households do not have under-6 years children, 360 (60.5%) households do not have members who are 60 years and above. Similarly, 234 and 156 households have 1 and 2 children below 6 years while 145 and 84 had members who are 60 years and above. These being the most vulnerable groups as far as malaria attack is concerned. This finding revealed that fewer households have higher numbers of vulnerable groups as far as malaria attacks is concerned. However, there is the need for households to adopt the use of insecticide treated nets (ITNs) to prevent malaria attacks by the households. World Malaria Report (2010) indicated that out of 7,296 reported mortality in children under 5 years in 2009, about 4,126 were linked to malaria.

Table 2. Demographic distributions of households' members

S/No	Age categories	Numbers								Total
		None (0)	1	2	3	4	5	6	7	
1	below 6	193	234	156	6	6	-	-	-	595
2	6-18	18	90	252	187	30	12	6	-	595
3	19-59	301	12	222	127	126	42	24	12	595
4	60 and above	360	145	84	6	-	-	-	-	595

Source: Field survey, 2025.

ITNs possession and usages among households

The findings of this study also revealed that out of 595 respondents' households, 427 (71.8%) had no ITNs (table 3). Also, 43 (7.2%) had 2 ITNs, while 83 (13.9%) and 42 (7.1%) had 3 and 4 ITNs, respectively. Similarly, only 50 (8.4%), 60 (10.1%) and 48 (8.1%) had 3, 4 and 5 households members sleeping under ITNs while 5(0.8%) and 4 (0.7%) had 6 and 9 members of households sleeping under ITNs in the night preceding the interview. In other word, only 28.2% of the sampled households have at least one (1) ITNs. It implies that majority of the households have no access to mosquito nets. This finding concurs with Eteng *et al*. (2014) who reported that ownership of mosquito nets is low among urban households in Nigeria. Similarly, Adekanye (2019) in a study conducted among rural farming households in South west Nigeria reported that only 7.1% of the households had access to mosquito nets (ITNs) while Miller *et al.* (2007) had earlier reported that only 13% of families in African have insecticide treated nets despite its effectiveness in preventing malaria.

Table 3. ITNs possession and Usages among households

Categories	Numbers										Total
	None (0)	1	2	3	4	5	6	7	8	9	
Number of ITNs in the house	427	-	43	83	42	-	-	-	-	-	595
Household members sleeping under ITNs	427	-	-	50	60	48	5	1	-	4	595

Source: Field survey, 2025

ITNs usage intensity among respondent households

This section examined the intensity (extent) of ITNs usage by the households. The table 4 below shows that 427 (71.8%) are not using ITNs at all, only 23.9% scored 0.5 and above on ITNs usage intensity rating. This implies that only 23.9% of the respondents' households have at least half of their household members sleeping under mosquito nets, a pointer to the fact that ITNs usage intensity compliance in the study area is very low. Hence, there is need to intensify efforts on free distribution of ITNs and also enlightenment campaign on the need to adopt sleeping under mosquito nets to reduce mosquito bites and incidence of malaria attacks. Eteng *et al.* (2014) in a similar research conducted in Cross River and Bauchi States, Nigeria reported that actual use of bednets for young children lags well behind the possession of bednets due to many fears and misconceptions about treated bednets which needs to be tackled in order to increase the use of bednets.

Table 4. ITNs usage intensity among respondent households

ITNs usage intensity	Frequency	Percentage of total
0	427	71.8
0.01-0.29	2	0.3
0.30-0.49	23	3.9
0.50-0.69	72	12.1
0.70-0.89	48	8.1
0.90-1.00	23	3.7
Total	**595**	**100**

Source: Field survey, 2025.

Tobit estimates of the determinants of ITNs usage intensity

The regression results of the determinants of ITNs usage intensity in the study area is presented in Table 5. With the sigma value of 0.1731 and *p* value of 0.0141 (significant at 5%), censoring matters and the use of Tobit model is appropriate and justified. Out of the eighteen independent variables included in the model, eight had significant influence on ITNs usage intensity. According to the results, the coefficient of the sex of household head was negative (β=-0.1666) and statistically significant. It infers that being a male-headed household reduces ITNs usage intensity by 0.1666 unit. In other word, being a female-headed household will increase ITN usage intensity. This finding concurs with the assertion of Garley *et al*., (2013) that gender matters in the utilization of insecticide-treated nets and reported that more females compared to males use malaria preventive intervention which includes the use of treated bednets and besides, women stay at home with children more than men and are more likely to ensure that their newborns and under-five children sleep under the bed nets. The coefficient of mothers' years of schooling was positive (β=0.0132) and statistically significant. It suggests that a unit increase in mother's years of schooling increases ITNs usage intensity by 0.0132. It implying that increase in mothers' level of education will increase the intensity0 of using ITNs. Recent studies by Nzelu *et al. (*2025), Haileselassie *et al*. (2023) and Yitayew *et al. (*2018) highlighted the positive impacts of education on the use of ITNs for malaria prevention.

The coefficient of number of pregnant women in the households was positive (β=0.110) and statistically significant. This implies that a unit increase in number of pregnant women in the household increases ITNs usage intensity by 0.1110 unit. Shame (2001) and CDCP (2011) reported that malaria in pregnant (MIP) women is a major risk factor of child death in the first month of life, causes about 15% of maternal anaemia and about 35% of preventable low birthweight, which is a leading cause of neonatal mortality. The coefficient of number of ITNs in the households was positive (β=0.1448) and statistically significant which suggests that a unit increase in number of ITNs in the households increases ITNs usage intensity by 0.1448 unit. Similarly, the coefficient of number of household members sleeping under ITNs was positive (β=0.1713) and statistically significant which infers that a unit increase in number of household members sleeping under ITNs increases ITNs usage intensity by 0.1713 unit. These findings concur with Solanke *et al.* (2023) who identified the number of treated bed nets and proportion of under-five children sleeping under bed nets in the households, among other factors, as important associated factors of the utilization of insecticide-treated nets in Northern Nigeria.

The coefficient of the presence of electricity in the house was negative (β=-0.1366) and statistically significant indicates that the presence of electricity in the house reduces ITNs usage intensity by 0.1366 unit. The availability and accessibility of electricity may reduce the need for mosquito nets uses as household members will sleep under electric fan that is capable of drives away mosquitoes before reaching its intended victim. Access to electricity to power electric fan improves comfort inside bed nets (VonSeidlein *et al.,* 2012; Hughes, 2014). Likewise, the coefficient of the presence of electric fan in the house was positive (β=0.1202) and statistically significant, suggesting that the presence of electric fan in the house increases ITNs usage intensity by 0.1202 unit. This might be due to the fact that the use of electric fan improves comfort inside bednets (VonSeidlein *et al*., 2012; Hughes, 2014) by reducing heat inside beds as heat is one of the major reasons given by some respondents in the previous researches for poor usage of mosquito nets (Pulford *et al*., 2011).

The coefficient of households percapita expenditure was negative ($1.39e^{-06}$) and statistically significant which indicates that a unit increase in households percapita expenditure reduces ITNs usage intensity compliance by $1.39e^{-06}$ unit. Although, the magnitude may be negligible but the direction of influence of the variable is highly important. This implying that households with higher percapita expenditure are wealthier than those with lower percapita expenditure, hence may have access to other sophisticated ways of controlling mosquito bites aside the use of mosquito nets. Alawode *et al.* (2019) observed that richer households were less likely to adopt the use of mosquito nets as frontline malaria prevention.

Table 5: Tobit estimates of ITNs usage intensity

Variables	Coefficient	Robust Standard error	T	P>|t|
Constant	-0.2190	0.1338	-1.64	0.102
Sex	-0.1666***	0.0454	-3.67	0.000
Household size	-0.0133	0.0102	-1.30	0.195
Years of schooling	-0.0042	0.0056	-0.75	0.453
Mother's years of schooling	0.0132*	0.0075	1.77	0.077
Children below 5 years	-0.0107	0.0179	-0.60	0.551
Number of pregnant women	0.1110***	0.0330	3.36	0.001
Number of people above 60	0.0246	0.0196	1.26	0.209
Number of ITNs in the households	0.1448***	0.0315	4.60	0.000
Number sleeping on ITNs	0.1713***	0.0183	9.35	0.000
OHIS enrollment status	0.0411	0.0325	1.27	0.206
NHIS enrollment status	9.33e-06	0.0275	0.00	1.000
Room density	0.0356	0.0779	0.46	0.648
Presence of electricity	-0.1366 **	0.0666	-2.05	0.041
Presence of electric fan	0.1202*	0.0673	1.78	0.075
Distance to irrigation/open water body like ponds	-0.0004	0.0038	-0.11	0.909
Distant to health centre	-0.0071	0.0048	-1.47	0.142
Participation in malaria awareness campaign	0.0700	0.0705	0.99	0.321
Households per capita expenditure	-1.39e-06***	4.57e-07	-3.04	0.002
/sigma	0.1731	0.0141		

****, **, and * indicate significance at 1%, 5% and 10% level, respectively. The values in parentheses are the standard errors.*
427 left-censored observations at itnusagein~y <= 0
146 uncensored observations
22 right-censored observations at itnusagein~y >= 1
Source: Field survey, 2025.

OLS estimates of the determinants of malaria prevalence in the study area

Data obtained were subjected to Ordinary Least Square (OLS) regression model to examine the influence of insecticide-treated net (ITNs) usage intensity and other determinants on malaria prevalence in the study area. As revealed by the table 6 below, the overall fit of the model was very good with the coefficient of determination (R^2) of 0.7658, implying that 76.6% of the variation in malaria episodes is explained by the regression equation. F-value for the model was statistically significant at 1%, implying that the model was well fitted to the data and results are reliable. Seven (7) variables were found to have statistically significant influence on the prevalence of malaria in the study area. The coefficient of sex was positive (β=3.6534) and statistically significant (p<0.1). This implying that being a male-headed household increases the incidence of malaria by 3.6534 unit. This might be due to the fact that men stay longer outside at night than their female counterparts. The finding however contradicts Kakuru *et al.* (2020) and Quaresima *et al.* (2021) who had earlier reported that women are more prone to malaria infection compared to men as a result of biological and social factors.

Furthermore, the coefficient of environment was negative (β=-0.7307) and statistically significant (p<0.1). That is, living in a clean environment will reduce the prevalence of malaria by 0.7307 units. It implies that living in a bushy and dirty environment will expose households to mosquito bites more than those in a clean environment. This finding agrees with Ogbuene *et al.* (2024) that the presence of bushes, stagnant waters around the houses and high temperatures, present a high risk of malaria transmission. Also, Dauda *et al.* (2023) reported that poor environmental sanitation practice has been strongly linked to high malaria transmission, morbidity and mortality rates especially in low and middle income countries such as Nigeria.

The coefficients of distance to water source for domestic use was also positive (β=4.6119) and statistically significant ($p<0.01$). It implies that a unit increase in the distance to water source for domestic use will lead to 4.6117 unit increase in the incidence of malaria in the household, this might be due to the increase in exposure to mosquito bites by the household members involved in sourcing the water. However, the coefficient of water source was negative (β=-0.8359) and statistically significant ($p<0.05$). This implies that access to modern source of water will reduce households' malaria incidence by 0.8359 unit. Access to modern sources of water like pipe-borne water or bore hole will reduce the households' exposure to mosquito bites when compared with the households who relied on local sources of water like stream and local wells. This finding concurs with Shayo *et al.* (2021) who reported in Tanzania that the regions and zones with a higher prevalence of malaria also has a higher percentage of non-piped water and that a non-piped source of domestic water was independently, significantly associated with malaria positivity, after excluding the influence of other environmental factors. Yang *et al.* (2020) also reported that water and sanitation conditions were important risk factors for malaria among children under-five years old across sub-Saharan Africa and that unimproved water and sanitation access (unprotected water; no facility) was related to a relatively high risk of malaria.

The coefficient of distance to irrigation or other open water body was negative (β=-0.1625) and statistically significant ($p<0.01$). This implies that a unit increase in distance to irrigation or other open water body will reduce the prevalence of malaria by 0.1625 units, as open water bodies promote breeding of mosquitoes. This finding concurs with Haileselassie *et al.*(2021) in a study conducted in Ethiopia in which it was observed that higher anopheline density was recorded in the irrigation areas compared to the non-irrigation areas and concluded that the irrigation scheme in the study area could increase the risk of malaria transmission in communities residing in proximity to the irrigation sites. Furthermore, the coefficient of number of people sleeping under ITNs in the house was negative (β=-0.9339) and statistically significant ($p<0.01$). This implies that a unit increase in the number of people sleeping under ITNs will reduce the prevalence of self-reported malaria by 0.9339 units. Fegan, *et al*. (2007) had reported 44% reduction in mortality due to the use of insecticide-treated bednets (ITNs). Lastly, the coefficient of ITNs usage intensity was negative (β=-5.0294) as expected and statistically significant ($p<0.05$). This implies that a unit increase in ITNs usage intensity will reduce the prevalence of malaria in the household by 5.0294 unit. Access to and sleeping under mosquito nets reduces the frequency of mosquito bites, hence less malaria attacks. Tangena *et al.* (2023) reported that ITN usage significantly reduces malaria prevalence, especially among vulnerable groups such as children and pregnant women. The use of ITNs is one of the most effective malaria prevention strategies as it reduces human–mosquito contact, thereby lowering infection rates.

Table 6. OLS estimates of the determinants of malaria prevalence in the study area

Dependent variable: Numbers of malaria episodes in households				
Independent Variables	Coefficient	Robust Standard error	t-value	P > | t |
Constant	14.0637***	2.1608	6.51	0.000
Sex	3.6534***	0.4844	7.54	0.000
Age of household head	0.0082	0.0235	0.35	0.727
Years of schooling	0.0467	0.0477	0.98	0.328
Household size	-0.0667	0.1303	-0.51	0.609
Children below 6 years	-0.0429	0.2279	-0.19	0.851
Number of pregnant women in the house	0.0426	0.6249	0.07	0.946
Number of people above 60 years	0.0523	0.2470	-0.21	0.832
Number of ITNs in the house	-0.1654	0.3564	-0.46	0.643
Number of people sleeping under ITNs	-0.9339***	0.2995	-3.12	0.002
Households enroll with OHIS	-0.1753	0.4552	-0.39	0.700
Households enroll with NHIS	-0.0904	0.3653	-0.25	0.805
Distance to the nearest health centre	-0.0817	0.0676	-1.21	0.227
Housing types (good or bad)	-0.0979	0.4813	-0.20	0.839
Environment (clean=1; dirty =0)	-0.7307*	0.4309	-1.70	0.091
Room density	-0.7896	1.0212	-0.77	0.440
Presence of electricity in the house	0.0778	0.7318	0.11	0.915
Presence of electric fan in the house	-1.0566	0.7498	-1.41	0.159
Distance to irrigation or other open water	-0.1625***	0.0530	-3.07	0.002
Water source (modern =1; traditional=0)	-0.8359**	0.3316	-2.52	0.012
Distance to water source for domestic use	4.6119***	1.4459	3.19	0.002
If floor is cemented	-0.1931	0.7719	-0.25	0.802
If roof is made of iron sheet	-0.9656	1.0456	-0.92	0.356
If the walls are plastered	1.3996	1.0855	1.29	0.198
Household per capita expenditure	-8.65e-06	6.68e-06	-1.30	0.196
ITNs usage intensity	-5.0294**	2.1679	-2.32	-0.021
F(25, 569) =	55.65			
Prob > F =	0.0000			
R-squared =	0.7658			
Root MSE =	35.9055			
No of Obs. =	595			

*** Significant at 1%, ** Significant at 5% and * Significant at 10%.
Source: Field survey, 2025.

CONCLUSION AND RECOMMENDATIONS

This study concluded that the use of insecticide treated bednet has the potential to reduce the frequency of mosquito bites and thereby reduce the frequency of malaria attacks on household members. That is, ITNs reduce human–mosquito contact, thereby lowering infection rates. Regrettably however, the percentage of households with at least an insecticide treated bednet and household members sleeping under insecticide treated bednets is abysmally low. Hence, there is need to increase free ITNs access via government/NGO partnerships and target vulnerable groups, especially the children under-5years, pregnant women and the aged people; there is need to boost rural electrification project to allow people at the rural areas to be able to use electric fans which increase comfort inside mosquito nets as heat is one of the major complaints of most people for not sleeping under mosquito nets; since types and distance to the source of water for domestic use are significant variables in the prevalence of malaria, government should intensify efforts in providing portable water for the people in the rural areas.

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DECLARATION OF CONFLICTING INTERESTS

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