

# Comparative Analysis of the Effects of Socio Economic Variables on Malaria Vulnerability in the Agro-Ecological Zones in Borno State

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## Abstract

*This study focussed on comparative analysis of the socioeconomic variables in relation to malaria vulnerability of the three agro-ecological zones of Borno State, that is, Sahel, Sudan and Guinea Savannah. The 2006 population figures of the following purposive sampled LGAs were projected to 2018: Biu and Shani (from Guinea Savannah), MMC, Gwoza and Damboa (from Sudan savannah and Gubio being the most accessible LGAs in Sahel during the study. Krejcie and Morgan table of sampling was adopted for the determination of the sample size in each of the six sampled LGAs. Eight hundred and forty-five (845) questionnaires were administered in the six sampled LGAs. Qualitative in-depth interview was also conducted for further clarifications on grey areas during the administration of the questionnaire to the household heads or individuals who are knowledgeable in the subject matter. Logistic regression was used in the analysis of the socio-economic factors for assessment of malaria vulnerability and prevalence. The results revealed that though there were variations in the outcome of the predictors, gender, occupation, income and vulnerable classes were significant in the Sahel ecological zone; gender, education, occupation, out-door, house type, vulnerable classes and sleeping under mosquito net were significant in Sudan savannah while only expenditure on health was significant in Guinea Savannah. It was suggested that Borno State government should device modern means of data acquisition with minimal human interference especially in the strongholds of the insurgents and to make such data available on line. The conditions for the variance in the significance of some predators among the three ecological zones is suggested for further studies.*

**Keywords:** *Agro-Ecological Zones, Borno State, Malaria Vulnerability, Logistic Regression, Social economic attributes*

## Introduction

The health of a person is a vital part of their life as it affects every aspect of their life experiences on the planet. The determinants of health are a range of factors: environment (physical, social, biological and manmade), behaviour (actions, habits, reactions, beliefs, attitudes and practices or lifestyles) and health services (promotive, preventive, curative, and rehabilitative) that influence the health status of an individual or population as summarized by Dahlgren and Whitehead (2012) and concluded that the higher a person's socio-economic status is, the more likely he or she is to enjoy good health. Malaria is now one of the most important diseases in tropical countries and its spread has been enhanced by factors such as

population growth, urbanization, the coming up of previously sparsely inhabited areas, migrations, refugees, and conflicts (Kabaria et al (2017).

World Malaria Report (2015) stated that in 2005, WHO proposed a goal to reduce the incidence of malaria, caused by Plasmodium infection, in endemic regions by 75% by 2015. Therefore, between 2000 and 2015, a number of malaria control measures were implemented which resulted in a 37% reduction and a 60% decrease in the mortality rate. Unfortunately, malaria is still a serious public health problem in developing countries. In 2016 alone, approximately 216 million people were infected, and an estimated 445,000 died due to malaria globally. About 90% of these malaria cases and 91% of deaths due to the disease were in Sub-Saharan Africa. More than 70% of deaths due to malaria in SSA in 2016 occurred in children under five (World Malaria Report 2015). World Health Organization report has it that malaria is responsible for more than 50% recorded deaths in Borno state and that children under the age of five are more vulnerable (WHO 2018).

Though, the presence of insecticide resistant mosquitoes (*Anopheles gambia ecomplex*) and favorable climate and environmental conditions, conducive to vector survival, makes malaria transmission high in Borno State, socioeconomic attributes including education, employment, income, and household are other contributing factors to the high burden of malaria. Most frequently, malaria is referred to as a disease of the poor and the economic status of the population at risk has proven to be a challenge in malaria control programmes (Enayiti & Hemingway 2019). The most effective way to reduce the incidence of malaria in a place like Borno State which is bedevilled by insurgency, civil unrest, poverty and malnutrition is by boosting malaria prevention and control through the assessment of socioeconomic attributes of the people and comparing one agro-ecological zone to the other, because a clear understanding of the effects of housing structure, education, occupation, income, and wealth on malaria in these zones can help to better design socioeconomic interventions to control the disease.

### **The Study Area**

Borno State is located between Latitudes 10° 0' 13.473"N and 13° 44' 40.23"N and Longitudes 11° 26' 20.555"E and 14° 34' 11.581"N (Fig.1). The State shares international boundaries with three countries, that is, Republics of Cameroon in the East, Chad in the North East and Niger in the North. The State also has boundaries with three States in Nigeria: Adamawa State in the South, Gombe State in South-West and Yobe State in the West (Fig.1). The present Borno State covers a total land area of 72,363.40 km<sup>2</sup> and consists of twenty-seven (27) Local Government Areas (LGAs). To study geographical variations, ecological zones present great advantages especially with respect to studying disease patterns (Akawu, 2021). FAO (2018), defines agro-ecological zones as combinations of soil, vegetation, landform and climatic characteristics of an area.

Sahel Savannah belt is the transition zone between the southern Sudan Savannah in Borno State and the desert regions in Niger Republic. Sahel Savannah currently covers a land area of 26,484.44 km<sup>2</sup>, that is, 36.6% of the total land area of Borno State (Akawu 2021). The entire land area of Abadam, Mobbar, Kukawa, Guzamala and Gubio LGAs as well as major land areas in Nganzai, Monguno, Marte and Magumeri LGAs are all within Sahel Savannah. The main characteristic of Sahel Savannah is sparse vegetation with plants such as *Ngibbi*, *Acacia raddiana*, *Leptadenia*, and *African myrrh* (Makinde, 2017). Major occupations of the inhabitants of the Sahel Savannah are nomadic herding and limited rain-fed agriculture with peanuts and millet as the major crops. Desertification has been the major challenges of the

Sahel vegetation (Nicholson 2013). The annual precipitation in the wet season lasts between 3 and 4 months, resulting into extremely short and scanty vegetation. The grasses do not grow more than one meter because of extremely low annual rainfall of less than 700 mm and long period of dry season that last up to nine months (Nicholson 2013). Eludoyin and Adelekan (2013) summarized the minimum and maximum temperature of the Sahel zone as 21.2 and 35.3°C respectively and the minimum and maximum relative humidity as 28.2 and 36.3% respectively. Therefore, the Sahel with low rainfall, low relative humidity and high temperature climatic conditions, do not favour rapid growth of the anopheles and hence, malaria prevalence is expected to be low in the zone.

### **Sudan Savannah**

Sudan Savannah currently and completely covers the following LGAs: Bama, Dikwa, Kaga, Gwoza, Jere, Kala Balge, Konduga and MMC as well as almost the whole land area of Mafa LGA (Figure 3.3). The southern parts of Gubio, Marte, Monguno, Magumeri and Ngala LGAs also fall in the Sudan zone. Sudan Savannah covers a total area of 32,753.58 km<sup>2</sup> which is about 45.26% of the entire land area of the state (Akawu 2021). Therefore, Sudan savannah is the largest Savannah belt in Borno State. The low average annual rainfall of 657.3 mm and the prolonged dry season (6-9 months) sustain fewer trees and shorter grasses than the Guinea Savannah. It is characterized by abundant short grasses of 1.5 – 2 m and few stunted trees hardly above 15 m. It is by far the most densely human populated zone in Borno State (Akawu, 2021). The grass vegetation is interspersed with farms and thick bush trees such as Shea Butter tree (*Butyrospermumparkii*) and *Acacia albida*, Locust Bean trees (*Parkiafilicoidea*), Tamarind tree (*Tamarindusindica*) and Mango (*Mangiferaindica*). The climatic conditions in the Sudan are more favourable for the survival of anopheles mosquitoes (Lazarus, 2015). Temperature is lower than that of the Sahel while relative humidity and rainfall are higher in the Sudan than the Sahel (Lazarus 2015). Therefore, malaria prevalence, based on climatic factors alone, are expected to be higher in Sudan savannah than the Sahel.

### **Guinea Savannah Zone**

Guinea covered the least land area among the three ecological zones in Borno State. It covered about 13,124.98 km<sup>2</sup>, which is only 18.14% of the total land area of the state (Akawu, 2021). The zone contains the full land areas of seven LGAs in the southern part of the state: Askira-Uba, Bayo, Biu, Chibok, Hawul, Kwaya Kusar and Shani LGAs. The southern part of Damboa LGA also falls within Guinea Savannah. The belt contains mixture of trees and tall grasses in the South, with shorter grasses and less trees in the North. The Guinea savannah is characterized by:

*Grasses, Pennisetum, Andropogon, Panicum, Chloris, Hyparrhenia, Paspalum and Melinis.* In the Guinea Savannah, species such as *Isobberliniadoka* and *I. tomentosa* form the bulk of the scattered woodland. Also found are Locust Bean trees (*Parkiafilicoidea*), Shea Butter trees (*Butyrospermumparkii*) and Mangoes (*Mangiferaindica*). Climatically, Guinea savannah zone has a unimodal rainfall distribution with average annual temperature and rainfall of 27.3°C and 1051.7mm respectively where the wet season lasts for 6–8 months. Since Guinea Savannah is characterized by denser vegetation, higher rainfall, and higher relative humidity, malaria prevalence would be higher in the zone than those of the Sahel and Sudan savannah. The extensive Biu Plateau in this zone with less temperature is however expected to experience less malaria prevalence than the surrounding because of the lower temperature.

## Methodology

The same method adopted by Akawu, et al, (2022) on the assessment of socioeconomic activities on malaria vulnerability in Borno State, is also adopted for this study. The Krejcie and Morgan (1970) table of sampling was adopted for the determination of the sampling size. Using the Table, 384 samples were from a million population. Therefore, the 2018 population of each LGA was projected based on the figures of the 2016 housing and population census at a growth rate of 2.59 (World Development Indicators, 2018) in each of the LGAs in Borno State. The equation for projecting population is  $N_t = P e^{(r * t)}$ . Where:

- "Nt" represents the number of people at a future time.
- "P" is the population at the beginning time.
- "e" is the base of the natural logarithms (2.71828).
- "r" is the rate of increase (natural increase divided by 100).
- "t" represents the time period involved.

This was summarized as: present population \* (base of the natural logarithms raised to (rate of natural increase /100 \* time period). To project the population of Damboa LGA in 2018 with population of 233200 in 2006, that is a period of twelve years: 233200 was the population in 2006 (p), the base of natural logarithms is 2.71828 (e), the rate of increase is 2.59 divided by 100 is 0.03 (r) while time difference is 12 (t). Table 3.3 shows the 2018 projected population of the sampled LGAs. Proportional method was used to determine the sample size of each LGA based on the 384 per million by dividing 1,000,000 by 384 and multiplied by the population of the LGA. For example, to obtain the number of sample size for Damboa LGA, the sample was determined by: Sample size =  $384/1000,000 * 314071 = 121$ . The same process was used for all the other sampled LGAs as shown in Table 1(The field work was done and data collected in 2019).

Table 1. Samples from each of the selected LGAs

| S/N | LGAs         | Population (2018 projected) | Samples    |
|-----|--------------|-----------------------------|------------|
| 1   | Biu          | 281146                      | 107        |
| 2   | Damboa       | 373027                      | 143        |
| 3   | Gubio        | 241,997                     | 92         |
| 4   | Gwoza        | 442398                      | 170        |
| 5   | Shani        | 161542                      | 62         |
| 6   | MMC          | 838810                      | 322        |
|     | <b>Total</b> | <b>2338920</b>              | <b>896</b> |

Source: Field work (2019)

For the administration of questionnaire in each LGA, purposive sampling technique (considering accessibility due to the ongoing security challenges in the state) was applied to sample the required numbers of LGAs. The entire northern part of the State was totally inaccessible during the period of this study which called for the selection of only one LGA that was a bit accessible (with security escort) during the data collection period. Three LGAs out of the eleven from Sudan with a total population of 3,625,771(54.55%) and two from Guinea Savannah out of the six LGA with population of 1,097,655 (16.51%) were selected. Therefore, Gubio, was selected from the Sahel Savanna zone, MMC, Gwoza and Damboa from the Sudan Savannah zone and Biu and Shani LGAs from the Guinea Savanna zone as shown in Figure 3.8. Based on this formula, eight hundred and ninety-six (896) questionnaires were administered in the six sampled LGAs. However, a total of eight hundred

and forty-five (845) which is about 94.3% of the total numbers of the questionnaire were returned. Qualitative in-depth interview was conducted for further clarifications or on grey areas during the administration of the questionnaire to the household heads or individuals who are knowledgeable in the subject matter. Key informant interview was also conducted in Gubio, MMC and Biu LGAs. The LGAs were purposively sampled based mainly on accessibility. The key informants comprised nine members: (i) Community head or representative, (ii) one male health worker (iii) one female health worker (iv) women leader (v) educationist (vi) female youth leader (vii) men youth leader (viii) one male household head (ix) one female household head.

Logistic regression was used in the analysis of the social economic factors for assessment of malaria vulnerability and prevalence. Logistic regression is a classification algorithm that is used where the response variable is categorical. The idea of Logistic Regression is to find a relationship between features and probability of particular outcome. For example, for determination of the factors or variables that influences the chances of a person contracting malaria or not over a period of time. Logistic regression gives a mathematical model that can be used to estimate the probability of someone not contracting malaria given certain independent variables. This is in contrast to linear regression analysis in which the dependent variable is a continuous variable. It actually measures the probability of a binary response as the value of response variable based on the mathematical equation relating it with the predictor variables. Logistic Regression is one of the basic and popular algorithms to solve classification problem. It is called 'Logistic Regression', because its underlying technique is quite the same as Linear Regression. The term "Logistic" is taken from the Logit function that is used in this method of classification

## **Results and Discussion**

### **Effects of Socioeconomic activities on malaria vulnerability in Sahel Savannah**

The analysis of the significant predictors in each of the ecological zones are shown in Tables 2-5. Based on the statistical results in Table 2, in the Sahel ecological zone only four (4) out of the eighteen (18) predictors are significantly associated to the outcome that is being infected with malaria. These include: gender, occupation, income and vulnerable classes.

### **Table 2. Effects of Socioeconomic activities on malaria vulnerability in Sahel Savannah**

*Comparative Analysis of the Effects of Socio Economic Variables on Malaria Vulnerability in the Agro-Ecological Zones in Borno State*

Table 2: Sahel

|   | Estimate | Std. Error | Z-Value | Pr(> z ) | Significance | α level  | Order of Significance |
|---|----------|------------|---------|----------|--------------|----------|-----------------------|
| (Intercept)                               | 11.5089  | 7.8146     | 1.473   | 0.14082  |              |          |                       |
| Female                                    | 5.7532   | 2.2902     | 2.512   | 0.01200  | Significant  | p ≤ 0.05 | 05                    |
| 25-34 Years                               | 2.1623   | 3.8991     | 0.555   | 0.57919  |              |          |                       |
| 35-44 Years                               | -14.120  | 3.5978     | -0.392  | 0.69473  |              |          |                       |
| 45-54 Years                               | -0.4247  | 3.2301     | -0.131  | 0.89539  |              |          |                       |
| 55 Years and Above                        | -1.2292  | 3.4692     | -0.354  | 0.72309  |              |          |                       |
| Marital Status                            | 0.4976   | 0.4231     | 1.176   | 0.23960  |              |          |                       |
| Secondary Education                       | 3.9314   | 2.2573     | 1.742   | 0.08157  |              |          |                       |
| Tertiary Education                        | 2.4673   | 3.2763     | 0.753   | 0.45140  |              |          |                       |
| Qur'anic Education                        | 1.609    | 1.5945     | 1.009   | 0.31292  |              |          |                       |
| Non-Formal Education                      | 1.426    | 1.4782     | 9.965   | 0.33467  |              |          |                       |
| Trading/Business                          | -8.2763  | 2.8082     | -2.947  | 0.00321  | Significant  | p ≤ 0.01 | 02                    |
| Civil/Public Servants                     | -9.4981  | 3.8342     | -2.477  | 0.01324  | Significant  | p ≤ 0.05 | 06                    |
| Others                                    | -2.938   | 2.6219     | -1.121  | 0.26249  |              |          |                       |
| 5,000-20,000 Naira                        | 3.0628   | 21,603     | 1.418   | 0.15626  |              |          |                       |
| 21,000-50,000 Naira                       | 8.533    | 2.9292     | 2.919   | 0.00351  | Significant  | p ≤ 0.01 | 03                    |
| 51,000 Naira and above                    | -0.9823  | 2.2816     | -0.431  | 0.66675  |              |          |                       |
| Engagement in Outdoor Activities          | -0.7991  | 0.9775     | -0.817  | 0.41366  |              |          |                       |
| Duration of Stay Outside in the Evening   | -0.6724  | 0.8067     | -0.833  | 0.40458  |              |          |                       |
| Location of Animal Shelter from Home      | -2.1394  | 1.145      | -1.868  | 0.06170  |              |          |                       |
| Homestead Close To Mosquito Breeding Site | -0.9106  | 0.9175     | -0.992  | 0.32097  |              |          |                       |
| Wooden House                              | 1.4167   | 1.7725     | 0.799   | 0.42414  |              |          |                       |
| Concrete House                            | 0.6395   | 1.3385     | 0.478   | 0.63278  |              |          |                       |
| Mosquito Net On Doors and Windows         | -0.789   | 1.4391     | -0.548  | 0.58352  |              |          |                       |
| Children Under % Years                    | -2.4178  | 1.5525     | -1.557  | 0.11938  |              |          |                       |
| Adults                                    | -5.0737  | 2.0093     | -2.525  | 0.01157  | Significant  | p ≤ 0.05 | 04                    |
| Pregnant Women                            | -5.261   | 1.76       | -2.989  | 0.00280  | Significant  | p ≤ 0.01 | 01                    |
| 5%-10% of Income                          | 0.5287   | 1.5143     | 0.349   | 0.72698  |              |          |                       |
| Greater than 10% of Income                | 0.6449   | 3.04       | 0.212   | 0.83200  |              |          |                       |
| Sleep Under Mosquito Net                  | 0.0224   | 1.3374     | 0.017   | 0.98664  |              |          |                       |
| 1-2 Months                                | -0.7067  | 2.3354     | -0.303  | 0.76218  |              |          |                       |
| 3-6 Months                                | 0.831    | 1.9851     | 0.419   | 0.67549  |              |          |                       |
| Greater than 6 Months                     | 3.8649   | 4.0456     | 0.955   | 0.33940  |              |          |                       |
| Spray the Environment                     | -0.9341  | 1.3405     | -0.697  | 0.48594  |              |          |                       |

Significance Codes: p ≤ 0.05 = 5% Level, p ≤ 0.01 = 1% Level, p ≤ 0.001 = 0.1% Level

Source: Logistic regression statistical analysis (2021)

The coefficient estimate of the variable gender for the factor female in Sahel is 5.7532, which is positive. This means that females have increased probability of being infected by malaria in relation to men. This finding is similar to that of David *et al*, (2016) where higher malaria prevalence was recorded among the females than the males in Maiduguri. Nas *et al*, (2017) also reported higher percentage of malaria prevalence in females than males in Kano, Nigeria. The coefficient estimates for trader/businessmen and civil servants in Sahel are -8.2763 and -9.4981 respectively, both negative meaning people in this category have associated decrease in probability of being infected with malaria. Akawu (2021) noted that in Borno State, an increase in income level is associated with an increased probability of not being infected by malaria. In the Sahel, those in the income bracket of 21,000-50,000 recorded a coefficient of 8.5330 indicating that for increase in income level, there is associated increase in the probability of not being infected with malaria. This finding agrees with that of Akawu (2021) that an increase in income level is associated with an increased probability of not being infected by malaria in Borno State. For the variable vulnerable people, the coefficient estimates of the groups adults and pregnant women are -5.0737 and -5.2610 respectively. This means that members of these groups have associated decreased probability of not being infected by malaria, that is, they are less vulnerable to malaria

### Effects of Socioeconomic activities on malaria vulnerability in Sudan Savannah

Table 3 shows the statistical results of the effect of socioeconomic activities in Sudan Savannah ecological zone. The Sudan Savannah ecological zone has the highest number of malaria predictors that are significant. In the Sudan ecological zone, only seven (7) out of the eighteen (18) predictors are significantly associated to the outcome. These include: gender, education, occupation, out-door, house type, vulnerable classes and sleeping under mosquito net.

**Table 3. Effects of Socioeconomic activities on malaria vulnerability in Sudan Savannah**

| Table 3: Sudan                            | Estimate | Std. Error | Z-Value | Pr(> z )  | Significance | $\alpha$ level | Order of Significance |
|---|----------|------------|---------|-----------|--------------|----------------|-----------------------|
| (Intercept)                               | 4.3925   | 7.15593    | 0.614   | 0.5393300 |              |                |                       |
| Dambo                                     | -0.37658 | 1.17958    | -0.319  | 0.7495370 |              |                |                       |
| Gwoza                                     | 0.14741  | 1.11918    | 0.132   | 0.8952150 |              |                |                       |
| Female                                    | -7.59555 | 1.80713    | -4.203  | 0.0000263 | Significant  | $p \leq 0.001$ | 03                    |
| 25-34 Years                               | 0.70401  | 1.59972    | 0.44    | 0.6598770 |              |                |                       |
| 35-44 Years                               | 0.3912   | 1.50953    | 0.259   | 0.7955160 |              |                |                       |
| 45-54 Years                               | 0.3956   | 1.41675    | 0.279   | 0.7800650 |              |                |                       |
| 55 Years and Above                        | -3.66403 | 2.14805    | -1.706  | 0.0880550 |              |                |                       |
| Marital Status                            | -0.40252 | 0.57209    | -0.704  | 0.4816790 |              |                |                       |
| Secondary Education                       | 1.29493  | 1.47064    | 0.881   | 0.3785770 |              |                |                       |
| Tertiary Education                        | 6.02567  | 1.75016    | 3.443   | 0.0005750 | Significant  | $p \leq 0.001$ | 04                    |
| Qur'anic Education                        | -1.47609 | 1.4998     | -0.984  | 0.3250210 |              |                |                       |
| Non-Formal Education                      | -1.59827 | 1.62869    | -0.981  | 0.3264360 |              |                |                       |
| Trading/Business                          | -6.32774 | 1.39184    | -4.546  | 0.0000055 | Significant  | $p \leq 0.001$ | 01                    |
| Civil/Public Servants                     | -4.61745 | 1.86669    | -2.474  | 0.0133760 | Significant  | $p \leq 0.05$  | 07                    |
| Others                                    | -0.64784 | 1.80342    | -0.359  | 0.7194220 |              |                |                       |
| 5,000-20,000 Naira                        | -1.21883 | 1.4813     | -0.823  | 0.4106140 |              |                |                       |
| 21,000-50,000 Naira                       | 2.17508  | 1.55778    | 1.396   | 0.1626330 |              |                |                       |
| 51,000 Naira and above                    | 0.16399  | 1.83302    | 0.089   | 0.9287130 |              |                |                       |
| Engagement in Outdoor Activities          | 4.06895  | 1.55658    | 2.614   | 0.0089480 | Significant  | $p \leq 0.01$  | 05                    |
| Duration of Stay Outside in the Evening   | -0.09051 | 0.77641    | -0.117  | 0.9072020 |              |                |                       |
| Location of Animal Shelter from Home      | 2.98401  | 1.59821    | 1.867   | 0.0618880 |              |                |                       |
| Homestead Close To Mosquito Breeding Site | 1.29078  | 1.5166     | 0.851   | 0.3947130 |              |                |                       |
| Wooden House                              | -1.50668 | 1.63227    | -0.923  | 0.3559760 |              |                |                       |
| Concrete House                            | -7.83394 | 1.77399    | -4.416  | 0.0000101 | Significant  | $p \leq 0.001$ | 02                    |
| Mosquito Net On Doors and Windows         | 1.79368  | 1.85252    | 0.968   | 0.3329260 |              |                |                       |
| Children Under % Years                    | -0.52931 | 1.11968    | -0.473  | 0.6364070 |              |                |                       |
| Adults                                    | -1.20109 | 1.06286    | -1.13   | 0.2584540 |              |                |                       |
| Pregnant Women                            | -3.103   | 1.29946    | -2.388  | 0.0169440 | Significant  | $p \leq 0.05$  | 08                    |
| 5%-10% of Income                          | -1.77241 | 1.27875    | -1.386  | 0.1657320 |              |                |                       |
| Greater than 10% of Income                | -1.49644 | 1.24108    | -1.206  | 0.2279140 |              |                |                       |
| Sleep Under Mosquito Net                  | -5.04929 | 1.96505    | -2.57   | 0.0101830 | Significant  | $p \leq 0.05$  | 06                    |
| 1-2 Months                                | 0.11148  | 1.72803    | 0.065   | 0.9485630 |              |                |                       |
| 3-6 Months                                | 2.52722  | 1.87172    | 1.35    | 0.1769490 |              |                |                       |
| Greater than 6 Months                     | -3.65543 | 2.05927    | -1.775  | 0.0758800 |              |                |                       |
| Spray the Environment                     | -1.01193 | 1.89097    | -0.535  | 0.5925530 |              |                |                       |

Significance Codes:  $p \leq 0.05$  = 5% Level,  $p \leq 0.01$  = 1% Level,  $p \leq 0.001$  = 0.1% Level

In the Sudan Zone, the coefficient estimate of the variable gender for the factor female is -7.59555, which is negative. This means that for females, there is associated decrease in the probability of not being infected as compared to men. That means women are more vulnerable than men. Individuals who had tertiary education, the coefficient estimate is 6.02567, that is increase in level education is associated with increase in the probability of not being infected by malaria. That is the lower the education level the more vulnerable an individual is. According to Ricci (2012), lack of education may be related to low levels of awareness about malaria prevention and treatment strategies. Snyman *et al*, (2015) also reported a lower risk of malaria among children whose parents had more than primary education compared to those with families who were illiterate or had a primary level of education. Degarege *et al*, (2019) showed greater odds of Plasmodium infection among

individuals with no formal education or were illiterate than those with primary or more education level. The coefficient estimates for traders/businessmen and civil servants are -6.32774 and -4.61745 respectively. This means that being member of these groups is associated with a decreased probability of being infected by malaria. This finding agrees with that of Degarege *et al.* (2019) that the odds of Plasmodium infection increased among farmers, or children with farming parents than individuals with non-agriculture related occupations. The coefficient estimate for Outdoor activities is 4.06895 which is positive and this means that an increase in outdoor activities is associated with increase in the probability of being infected by malaria. Monroe, *et. al* (2015) reported that outdoor sleeping and other night-time social, cultural and economic activities increase exposure to infective mosquito bites and malaria prevalence.

The type of the house an individual lives in is significantly associated with the chances of being infected with malaria. The concrete house type has a coefficient of -7.83394 which is negative, meaning that living in concrete house has an associated decrease in the probability of being infected. This finding has already been established by Lindsay *et al.*, (2003) in Degarege *et al.* (2019) that poorly constructed houses allow easy entrance of plasmodium-carrying vectors and increases chances of infection among family members. For the vulnerable people, the only factor level that is significant is the pregnant women group which has estimated coefficient of -3.10300, that is negative meaning that those in this group have an associated decreased probability of not being infected. Gontie, *et al.*, (2020) has already found out that the frequency and density of *plasmodium falciparum* malaria was high during pregnancy. David, *et al.*, (2016) also noted that pregnant women, children below five years and non-immuned individuals are at greater risk of infection and death from malaria. The coefficient for the variable sleeping under mosquito net is -5.04929 which is negative, hence an associated decreased probability of being infected

### **Effects of Socioeconomic activities on malaria vulnerability in Guinea Savannah**

Table 4 shows the statistical results of the effect of socioeconomic activities in Sudan Savannah ecological zone.

### **Table 4. Effects of Socioeconomic activities on malaria vulnerability in Guinea Savannah**

Table4: Guinea

|   | Estimate  | Std. Error | Z-Value | Pr(> z ) | Significance | $\alpha$ level |
|---|-----------|------------|---------|----------|--------------|----------------|
| (Intercept)                               | -8.668564 | 7.402067   | -1.171  | 0.2416   |              |                |
| Shani                                     | -1.087906 | 1.769371   | -0.615  | 0.5387   |              |                |
| Female                                    | 0.919377  | 1.621249   | 0.567   | 0.5707   |              |                |
| 25-34 Years                               | -0.96422  | 1.687119   | -0.572  | 0.5676   |              |                |
| 35-44 Years                               | 0.884023  | 1.612364   | 0.548   | 0.5835   |              |                |
| 45-54 Years                               | 3.327317  | 2.270253   | 1.466   | 0.1428   |              |                |
| 55 Years and Above                        | 0.775206  | 2.240988   | 0.346   | 0.7294   |              |                |
| Marital Status                            | 2.119492  | 1.332598   | 1.59    | 0.1117   |              |                |
| Secondary Education                       | 0.40096   | 1.551127   | 0.258   | 0.796    |              |                |
| Tertiary Education                        | -0.268182 | 1.640909   | -0.163  | 0.8702   |              |                |
| Qur'anic Education                        | 0.43183   | 1.826542   | 0.236   | 0.8131   |              |                |
| Non-Formal Education                      | 0.704369  | 2.229262   | 0.316   | 0.752    |              |                |
| Trading/Business                          | 0.003208  | 1.424283   | 0.002   | 0.9982   |              |                |
| Civil/Public Servants                     | 0.896118  | 2.275179   | 0.394   | 0.6937   |              |                |
| Others                                    | 0.006682  | 2.47976    | 0.003   | 0.9978   |              |                |
| 5,000-20,000 Naira                        | 0.979648  | 1.535996   | 0.638   | 0.5236   |              |                |
| 21,000-50,000 Naira                       | 2.32415   | 2.006284   | 1.158   | 0.2467   |              |                |
| 51,000 Naira and above                    | 0.216616  | 2.243097   | 0.097   | 0.9231   |              |                |
| Engagement in Outdoor Activities          | 1.962085  | 2.171703   | 0.903   | 0.3663   |              |                |
| Duration of Stay Outside in the Evening   | -0.534905 | 1.309985   | -0.408  | 0.683    |              |                |
| Location of Animal Shelter from Home      | 0.377942  | 1.494041   | 0.253   | 0.8003   |              |                |
| Homestead Close To Mosquito Breeding Site | -0.474808 | 1.442987   | -0.329  | 0.7421   |              |                |
| Wooden House                              | 0.960262  | 1.506004   | 0.638   | 0.5237   |              |                |
| Concrete House                            | 0.423314  | 1.452198   | 0.291   | 0.7707   |              |                |
| Mosquito Net On Doors and Windows         | -0.237929 | 1.535911   | -0.155  | 0.8769   |              |                |
| Children Under % Years                    | 2.652427  | 1.495507   | 1.774   | 0.0761   |              |                |
| Adults                                    | 2.458718  | 2.247163   | 1.094   | 0.2739   |              |                |
| Pregnant Women                            | 1.022611  | 2.301902   | 0.444   | 0.6569   |              |                |
| 5%-10% of Income                          | -3.460402 | 1.38582    | -2.497  | 0.0125   | Significant  | $p \leq 0.05$  |
| Greater than 10% of Income                | -1.883753 | 2.23472    | -0.843  | 0.3993   |              |                |
| Sleep Under Mosquito Net                  | 2.470628  | 1.940948   | 1.273   | 0.2031   |              |                |
| 1-2 Months                                | 0.653428  | 1.726318   | 0.379   | 0.7051   |              |                |
| 3-6 Months                                | -0.279902 | 1.638123   | -0.171  | 0.8643   |              |                |
| Greater than 6 Months                     | 0.617265  | 1.863198   | 0.331   | 0.7404   |              |                |
| Spray the Environment                     | -0.60339  | 1.484504   | -0.406  | 0.6844   |              |                |

Significance Codes:  $p \leq 0.05$  = 5% Level,  $p \leq 0.01$  = 1% Level,  $p \leq 0.001$  = 0.1% Level

In Guinea Savannah ecological zone, the only malaria predictor that is significant is expenditure on health which has estimated positive coefficient of 3.460402. That is, the higher the expenditure on health, the lower the likelihood of malaria infection. Information obtained FGD reveals that many of the users of herbal treatment were doing so because of financial incapability to use modern repellents, while many also use both herbs and drugs obtained from health centres together for treatment of malaria which is similar to the work of Njama *et al*, (2003) where it was noted that individuals with low income cannot easily afford to buy chemicals to spray in their houses, insecticide treated bed nets (in countries where they are not provided for free), and drugs or other related medical costs. This finding suggests that all the assessed malaria predictors have little or no effect on malaria prevalence in the Guinea Savannah ecological zone. Malaria vulnerability in this zone therefore, may largely depends on environmental factors like rainfall, temperature, humidity, relief among others as revealed in this study.

## **Conclusion**

Comparative analysis of the effect of socioeconomic variables on malaria vulnerability among the three agro-ecological zones in Borno State has been assessed in this study. While gender, occupation, income and vulnerable classes were the significant predictors in the Sahel zone, gender, education, occupation, out-door, house type, vulnerable classes and sleeping under mosquito net were significant in the Sudan Zone. In Guinea Savannah, only expenditure on health was significant. These significant predictors can serve as guide for malaria control by the stake holders. Since the significance of gender, occupation and vulnerable classes cut across both Sahel and Sudan Savannah, emphasis should be placed on the three predictors in the zones for effective malaria control. It was also established in this study that lucrative occupation and higher education attainment can reduce malaria prevalence. In the Guinea Savannah zone, with vast land area that are geographically conducive for malaria was found to be faced with the problem of expenditure on health which is also related to inadequate lucrative occupation in the state. The conditions for the variance in the significance of some predictors among the three ecological zones is suggested for further studies.

## **Recommendation**

Borno State government should device modern means of data acquisition with minimal human interference in order to make data available especially in the strongholds of the insurgents. Such data should also be available on-line.

Gender, occupation and vulnerable classes predators should be more emphasized in the Sahel and Sudan ecological zone

Government should emphasize on education and good occupation as these two attributes are major determinant of malaria occurrences

Proper and effective awareness should be created among the inhabitants of Sahel and Sudan ecological zones on the impact of negative out-door activities and poorly designed house types on malaria prevalence.

## References

- Akawu, C. (2021). Geospatial analysis of malaria prevalence and vulnerability in Borno State. An unpublished Ph.D. thesis, Department of Geography, University of Maiduguri, Nigeria.
- David, J., Anaso, E.C. and Ozurumba-Dwight, L.N. (2016). Prevalence of malaria in a study population in Maiduguri. Symptomatic manifestations and public health implications. *Greener journal of biological sciences* 6(9): 103-111.
- Degarege A, Fennie K, Degarege D, Chennupati S, Madhivanan P (2019) Improving socioeconomic status may reduce the burden of malaria in Sub-Saharan Africa: A systematic review and meta-analysis. *PLoS ONE* 14(1):pp205-211 <https://doi.org/10.1371/journal.pone>
- Eludoyin O.M. and Adelekan, I.O. (2013): Physiologic climate of Nigeria. *Int J Biometeorol*, March, 2013 57(2)241-64 doi:10.1007/s00484-012-0549-3
- Enayiti A, Hemingway J: Malaria management: Past present and future. *Annu Rev Entomol.* 2019,55: 569-591
- FAO (2018) [Agro-ecological zoning](http://www.fao.org/3/w2962e/w2962e-03.htm). Retrieved from <http://www.fao.org/3/w2962e/w2962e-03.htm>. Federal Ministry of Environment, Federal Republic of Nigeria. January, 2019.
- Gontie, G.B., Wolde, H.F. & Baraki, A.G (2020). Prevalence and associated factors of malaria among pregnant women in Sherkole district, Benishangul Gumuz regional state, West Ethiopia. *BMC Infect Dis* 20, 573. <https://doi.org/10.1186/s12879-020-05289-9>
- Kabaria, C.W., Gilbert, M., Noor, A.M. (2017). The impact of urbanization and population density on childhood *Plasmodium falciparum* parasite prevalence rates in Africa. *Malar J* 16, 49. <https://doi.org/10.1186/s12936-017-1694-2>
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and psychological measurement*, 30(3), 607-610.
- Lazarus, M. S. (2015). A study on the malaria vector (anopheles spp) in a Sudano-Sahelian Savannah area of Borno State, North Eastern Nigeria and the insect growth regulator pyriproxyfen (s-31183). An Unpublished thesis submitted to the Department of Zoology, Faculty of Natural Sciences, for the award of the degree of Doctor of Philosophy of the University of Jos
- Makinde, E. (2017). Vegetation zones in Nigeria and their features: Retrieved from <https://www.legit.ng/1096264-vegetation-zones-nigeria-features.html> 25/05/2020
- Monroe, A., Asamoah, O., Lam, Y., Koenker, H., Psychas, P., Lynch, M., Ricotta, E., Hornston, S., Berman, A., & Harvey, S. (2015). Outdoor-sleeping and other night-time activities in northern Ghana: Implications for residual transmission and malaria prevention. *Malaria journal.* 14. 35. [10.1186/s12936-015-0543-4](https://doi.org/10.1186/s12936-015-0543-4).
- Nas, F.S., Yahaya, A. and Ali, M. (2017). Prevalence of Malaria with respect to age, gender and socio-economic status of fever related patients in Kano City, Nigeria. *Greater Journal of epidemiology and Public Health.* Vol 5 (15) Sept., 2017 Pp 44-49

- Nicholson, S.E. (2013). The West African Sahel: A review of recent studies on the rainfall regime and its inter-annual variability. *International Scholarly Research Notices* / 2013
- Njama, D., Dorsey, G., Guwatudde, D., Kigonya, K., Greenhouse, B. and Musisi, S. (2003): Urban malaria: primary caregivers' knowledge, attitudes, practices and predictors of malaria incidence in a cohort of Ugandan children. *Trop Med Int Health*. 2003; 8(8):685–92. PMID: 12869089
- Ricci, F. (2012): Social implications of malaria and their relationships with poverty. *Mediterr J Hematol Infect Dis*. 2012; 4(1):e2012048. <https://doi.org/10.4084/MJHID.2012.048> PMID: 22973492
- Snyman, K., Mwangwa, F., Bigira, V., Kapisi, J., Clark, T.D, and Osterbauer, B (2015): Poor housing construction associated with increased malaria incidence in a cohort of young Ugandan children. *Am J Trop Med Hyg*. 2015; 92(6):1207–13. <https://doi.org/10.4269/ajtmh.14-0828> PMID: 25870429
- World Development Indicators (2018). Population Growth ( Nigeria). Retrieved from <http://data.worldbank.org/indicators/SP.POP.GROWTH>
- World malaria report (2015). Available from: [http://apps.who.int/iris/bitstream/10665/200018/1/9789241565158\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/200018/1/9789241565158_eng.pdf). [Accessed January 9, 2023]