



Geospatial Mapping Of Malaria Susceptibility in Suleja Local Government of Niger State, Nigeria

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Abstract

The accurate measurement of malaria incidence is essential to track progress and target high-risk populations. While health management information system (HMIS) data provide counts (occurrences) of malaria cases, quantifying the denominator for incidence using these data is challenging because catchment areas and care-seeking behaviors are not well defined. This study seeks to investigate malaria incidence rate (persons infected with malaria) in Suleja local government area (LGA) of Niger state. Malaria time series datasets data (2014-2022) was retrieved from the Ministry of health, Niger state. The dataset was sorted, filtered and refined for missing data using linear interpolation method. Statistical tools such as Bar chart and simple least square regression analyses tool was used to represent the malaria vector data at each ward and to estimate the malaria occurrence rate in the next ten years. At 95% confidence level, the malaria susceptibility rate was estimated to be fifty-six thousand four hundred and thirty-eight (56,438) persons infected with malaria vector in the LGA in the next ten years. The number of persons to be infected is quite disturbing when compared to the total population density of the LGA. However, the veracity of the research needs to be investigated by the LGA, this will aid in making policies and law relative to the causes of the high breed of female Anopheles mosquitoes in the LGA.

Keywords: Malaria Susceptibility, Plasmodium Falciparum, Female Anopheles Mosquitoes, Indiscriminate Solid Waste Dumpsite, Demographic, Mortality Rate.

1. Introduction

Malaria is a protozoan infection in humans which is mainly caused by the parasite called Plasmodium. It's classified into four main species *P. falciparum*, *P. ovale*, *P. malaria* and *P. vivax* (Jame *et al.*, 1996). *Plasmodium falciparum* is the agent of the most malignant form of malaria, usually presenting with severity mostly in children in sub-Saharan Africa (WHO 2019). It is the most dangerous form of malaria with the highest rates of complications. It is also the commonest species in virtually all parts of Africa accounting for up to 98% of the confirmed cases in Nigeria and is associated with significant morbidity and mortality (WHO) (2010). Malaria is known as a serious health challenge in tropical and subtropical regions of African and the world at large. It has far-reaching medical, social and economic consequences for the countries in which it is endemic, due to its high and alarming morbidity and mortality rates. Each year, approximately 2.5 million people die of malaria, many of whom are children. According to (USAID, 2010) estimates, 40% of the population of the world live in areas where malaria is endemic with the direct and indirect costs of management being very high.

Malaria affects five times as many people as AIDS, leprosy, measles and tuberculosis combined (WHO/UNICEF, 2003). WHO (2015) put malaria cases in the Africa region at 86% of the world malaria menace with 80% of the cases occurring in 13 countries in Africa. Malaria poses a serious threat to the health of pregnant women and young children in sub-Saharan Africa and other tropical regions of the world. More than 45 million women (30 million of them in Africa) become pregnant in malaria endemic areas each year (Shulman *et al.*, 1999; Steketee *et al.*, 2001). The population at high risk of malaria incidence in Nigeria is estimated at 135,552,389 (WHO, 2015). The country's confirmed and suspected cases of Malaria incidence as at 2015, stood at 19,555,575 people (WHO) (2015). Among vector-borne diseases, the malaria is influenced by seasonal or spatial changes in the environment (Messina *et al.*, 2011). Environmental factors such as the presence of bushes and stagnant water around homes, rainfall, low altitude and high temperatures favor the breeding of malaria vectors, as well as parasite reproduction within them (Messina *et al.*, 2011). Malaria has, therefore, been defined as an environmental disease (Hay *et al.*, 2000).

Tropical areas including Nigeria have the best combination of adequate rainfall, temperature and humidity allowing for breeding and survival of anopheles mosquitoes (Efe *et al.*, 2013). An increase in rainfall and temperature enhances mosquito development and improved breeding sites leading to incidence of malaria (Vincent and Sunday, 2015). Rainfall provides the breeding sites for mosquitoes and increases relative humidity necessary for mosquito survival,

leading to increase in the number of mosquitoes biting an individual per unit time (Lindsay and Martens, 1998). An adult mosquito's chance of survivorship is determined by the ambient temperature, humidity and rainfall. Warmer ambient temperatures shorten the duration of the extrinsic cycle, thus increasing the chances of transmission (Jackson *et al.*, 2010).

Malaria pandemic alone has caught the attention of both the local authorities and international agencies. Several measures have been adopted to reduce the rate of morbidity due to malaria. It is believed that climatic parameters had changed significantly over the past two/three decades (Akinbola *et al.*, 2010). Hence, a deeper knowledge of environmental variables, conducive to mosquito vector life cycle, is important to target control interventions. The objective of this research is to map out the areas susceptible to malaria in Suleja Local area from data retrieved from ministry of health of the state across all the wards . using geospatial techniques in depicting the wards which is most affected by person with malaria with the sole purpose of reducing, mitigating the effect of malaria infection in the LGA

2. Study Area

Suleja local government Area (LGA) is one of the oldest LGA in Niger State. It was created in the year 1976, its one among the Twenty-five 25 Local Government in Niger State. It is located between latitude 090 08' 00.16"N to 90 16' 00.17" and longitude 070 08' 00.13" E to 070 12' 00.13" E situated about 20km north of Abuja the Federal Capital of Nigeria. It is about 100km south east of Minna the Administrative Headquarters of Niger State. Suleja LGA enjoys sub-humid climatic condition with mean annual rainfall and temperature of 1640mm and raining season of over five (5) months in the year. There is a single maximum in the rainfall regime usually in the month of August. Temperature are generally high during summer, but cool during the harmattan which last from November to March Suleja master plan (1987-2006). This provides favorable breeding condition for the malaria vector and enhances occurrence, intensity and length of malaria transmission. Figure 1.1, depicts the map of the study area,



Figure 1: Map of Nigeria to the right up, map of Nigeria to the right down and map of the study Suleja Local government area to the left.

3. Method

3.1 Data Acquisition

The primary data was retrieved from Ministry of health, Niger state with the collaboration of the Primary Health Care (PHC) provider in the Suleja LGA. Table 1 summarized the data used for the research. The dataset cut across all the ten wards that constitute the LGA for the period of nine (9) years (2014-2022). The (Persons with Confirmed Cases of Malaria) dataset was sorted and refined for the missing data. The interpolation technique was used to predict the missing data. equation 1 depict the linear interpolation model (Pedro *et al.*, 2003)

$$y = y_1 + (y_2 - y_1) * \frac{x - x_1}{x_2 - x_1}$$

1

Where:

x : Independent variable

x_1 : Dependent Variable of the first known data point before x

x_2 : Independent Variable of the second known data point before x

y_1 : Dependent Variable corresponding to x_1

y_2 : Dependent Variable corresponding to x_2

y : Interpolated value

Table 1. Dataset Used for the Research

Type	Resolution	source	Relevance
Shape File	30*30 Pixel	USGS	Delineate each words
Administration Map	1.300,000	OSGOF	Validate the wards
Malaria Vectors		NSMH	Affection rate

Geographic informatics system (GIS) tool aid with remotely sense data were used to plot the spatial distribution map showing the level of malaria infected person across the state. Statistical tools such as bar chat and simple least square regression analyses was used to represent data and also make prediction of malaria vectors for the next ten years internal.

The projection was executed using a simple least square regression method to find the line (or curve) that best fits a set of data points. It works by minimizing the sum of the squared differences between the observed (y) values and the values predicted by the regression line for each corresponding (x) value. In simpler terms, the principle involves finding the line closest to all the data points. According to Douglas *et al.*, (2013), the relationship between (y) and (X)

$$y = mx + b \quad 2$$

Where

(m); slope of the line (coefficient of x), (b): y-intercept (the point where the line crosses the y-axis). To compute the values of (m) and (b) that best fits the data; you can use the following.

$$m = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad 3$$

$$b = \frac{\sum y - m(\sum x)}{n} \quad 4$$

Where

n :The number of data points, $\sum x$: the sum of all (x) values, $\sum y$:The sum of all (y) values, $\sum xy$: The sum of the products of each (x) and (y) pair, $\sum(x)^2$ Is the sum of the squares of each (x)

4. Result and Discussion

Table 4.1, depicts the names of ten (10) wards that constitute Suleja local government area (LGA) of Niger state, Nigeria.

Table 4.1. Wards of Suleja LGA

i	Bagama A	ii	Bagama B	iii	Hashimi A	iv	Hashimi B
v	Iku I	vi	Iku II	vii	Kurmi sarki	viii	Magijiya
ix	Maji	x	Wambai				

Suleja LGA is the second largest in population density and the also the second highest in terms internal generated revenue for the state (NGS, 2012). This could tell how relevant it is to the state Government. The geographical location of the LGA is an advantage, been it close to the Federal Capital Territory (FCT) Abuja gave it an edge over other LGAs in the state.

4.1 Malaria Susceptibility Rate across the wards of Suleja LGA

The malaria occurrences over the past nine (9) years in Suleja LGA is disturbing. There is need to understanding the magnitude at various wards and also the causes. Figure 2, depicts the spatial distribution of malaria infection rate across the LGA.

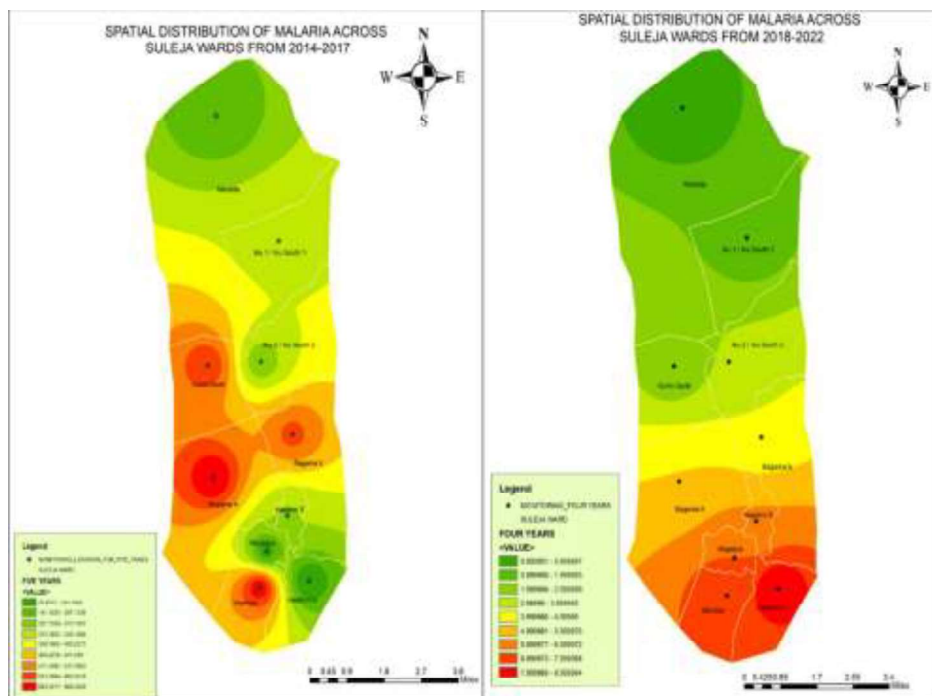


Figure 2. Spatial Distribution of Malaria Vector in Suleja LGA from the Year 2014-2017 at the left while from the year 2018-2022 at the right side

The year 2014, a total number of seventeen thousand, three hundred and eighty six (17,386) people were infected with malaria bacteria which translate to be 5.23% when compared with nine (9) years data. It was confirmed that Hashimi (A) ward recorded the highest number of persons infected with malaria with about 25.81% while Magajiya wards recorded the lowest with about 2.39%. The highest occurrence was recorded between the months of June and July. This corroborate with DWB (2020), breeding of mosquitoes anopheles is highly predominant during raining season. In the year 2015, the number of persons with malaria infection experienced an upward trend pattern of about 1.45% increase when compared with the previous epoch. Hashimi ward A recorded the highest number of infected persons having about 20.28% while Wambai ward recorded the lowest with about 1.65%. The highest number of malaria patients occurs during the months of August and September which happen to be raining season. The year 2016 also indicated an upward trend pattern, it recorded an increase of 3.45% compared to the previous epoch. The continuous increase indicated the fear of malaria outbreak in the LGA. The highest number of occurrences was recorded in Hashimi A with about 20.15% while the lowest was recorded at Wambai ward with about 0.5%. Wambai ward is experiencing a downward movement in it trend pattern which shows a level of check from the indigene. The highest value of malaria vector was recorded between the month of august and September. The year 2017 indicated an upward trend pattern of number of persons infected by malaria, it recorded about 1.51% increase compared with the previous year. This also shows an increasing trend for the years in view and it calls for concerns. Hashimi (A) ward recorded the highest number of infected patients, having about 21.07% while wambai ward maintained it position of been the lowest with about 0.37%. The year 2018 also indicated a positive trend, it recorded an increase of about 0.14%, while the increase cannot be compared with the previous years. However, Iku (I) recorded the highest number of persons infected with malaria vector having about 20.81% and Wambai ward remains the lowest having recorded about 2.30%. The trend of wambai ward is disturbing as it recorded a negative trend compared to the last three epochs. The months of highest occurrences fall within the raining season.

The year 2019 indicated a downward trend pattern, it recorded a decrease of 0.38% compared with the previous years. The rate is still disturbing as at the year 2019, the reduction is infinite compared to the ratio of the number of infected persons. Hashimi A ward regain the position of the highest infected persons with malaria while Wambai maintained its position as the least with a decreasing trend pattern of 1.96% and the highest was attained in raining season. The year 2020 indicated a positive trend, it recorded an upward movement of about 1.07% compared with the previous epoch. This also indicated an acute jump from the previous year. Hashimi A ward was the highest in terms of persons with infected cases of malaria having recorded about 18.035% of forty-one thousand four hundred and thirty (41,430) malaria cases recorded in the ward for the year 2020. Wambai ward recorded the lower of about 1.80%, the trend

pattern is decreasing for the past three epochs which suggest that authority in charge are putting hands on desk to checkmate the trend.

The year 2021 indicated an acute jump compared from the previous year, it recorded an increase of about 3.28% compared to the previous. Maje ward recorded the highest malaria vector infection with about 20.85% while 1.93% was recorded at Wambai ward as the lowest. The highest infection rate was experienced within the month of August and September. The year 2022 indicated a negative trend pattern, it recorded a downward movement of about 0.81%. However, Iku (II) ward was the highest in terms of malaria vector infection rate with about 21.26% while Wambai ward maintain the lowest position with about 2.24% of the total infection for the year. The total of about three hundred and thirty-two thousand, two hundred and eighty-five (332, 285) confirmed cases of malaria for the span of nine years at Suleja LGA. This is quite disturbing and its calls for urgent attention, as for the causes of continuous rises in the trend. The study also confined the claimed of World Malaria Report (2019), Nigeria had the highest number of global malaria cases (26.6 % of global malaria cases) and the highest number of deaths (31 % of global malaria deaths) in 2021. There is possibility that due to the outrageous growth in persons infected by malaria vectors, there could be death casualty amidst the high number recorded. However, there was no proof as to data was recorded the number of deaths incurred. Figure 3 summarized the trend pattern of malaria vectors (mosquitoes) persons infected for the period of nine years in Suleja LGA of Niger state.

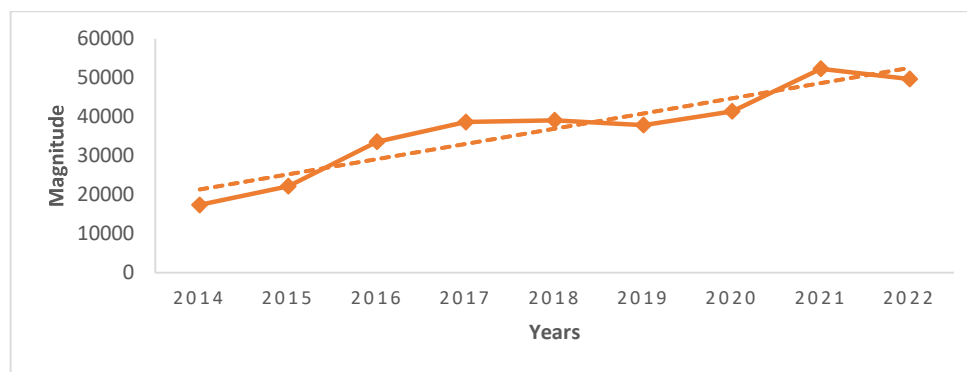


Figure 3. Trend Pattern of Malaria Vectors Infected Persons in Suleja LGA

4.3 Projection of Malaria Vector

Using simple linear least square equation to estimate the projection of the malaria vectors as it infects persons in the LGA. The projection sample equation was developed using the two variables, time as the independent data and malaria occurrences data as the dependent data. The projection model was $y = 17398 + 3904x$. Hence the projection of malaria vector infection in the next ten years will be fifty-six thousand, four hundred and thirty-eight (56, 438) persons is projected to be infected by malaria vectors by the year 2032. Figure 4. depicts the malaria anopheles infected persons rate projection to the year 2032 in Suleja LGA, Niger state, Nigeria

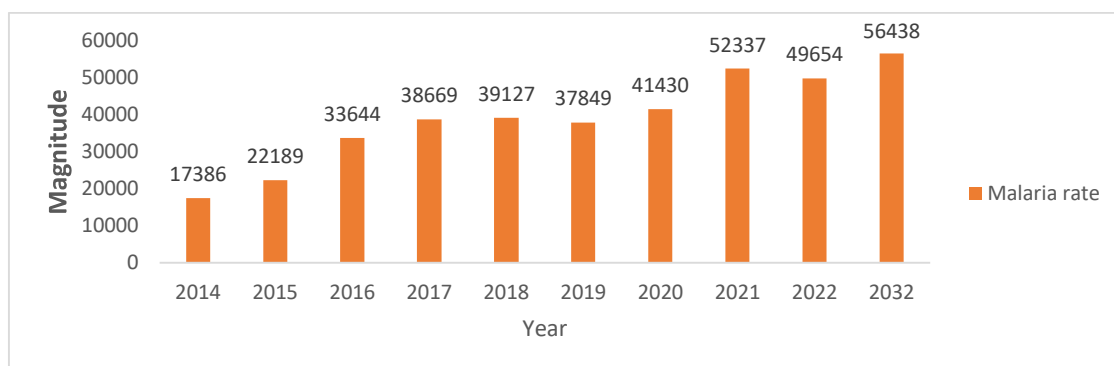


Figure 4. Malaria Projection for the year 2032 in Suleja LGA, Niger State

5. Conclusion

Malaria susceptibility rate in Suleja LGA is on the increase, this was confirmed from the trend pattern judging from the nine years datasets that was analyses. The wards of the local government areas are on a timebomb. Disease outbreak

could break out from the wards which could result to the loss of lives. There is need for the local authority responsible to do investigation on the remote causes of the high infections rate. It was also observed that while other wards malaria susceptible rate was increasing such as Hashimi A, Iku I and II, Maje etc some wards were also experiencing a downward slope of malaria occurrences such as Wambe, Bagama A and B. This can infer that, these wards that are experiencing downward trend are monitoring their attitudes towards clean environment and the possible causes of the causes. From the analyses, by the year 2032, the malaria bacteria vector will rise to about fifty-eight thousand, four hundred and thirty-eight (58,438) persons with malaria anopheles. Juxtaposing such number of infected persons with the population density of the LGA, this further confirmed the claimed of Nigeria been having the highest malaria cases of about 26% of the global cases (WHO) (2019).

The steps and condition slated by environmental protection agency, if abided to, it will go a long way in reducing the rate of malaria bacteria vectors in the various wards. Hashimi A wards continuously being the highest for almost 8years, it was also confirmed that the position of the wards in relative to the number of indiscriminate waste site and the earth gravity drainage which seems to be the major causes of the bacteria vectors growth. The breeding of plasmodium Anopheles mosquitoes from the number of indiscriminate waste site and the drainage have resulted to the increasing rate of malaria susceptibility.

Reference

- Chuang, I., & Richie, T. L. (2012). World malaria report 2010: documenting progress towards malaria eradication. *Expert review of vaccines*, 11(1), 39-41.
- Douglas, C., Montgomery, E. A., & Peck, G. G. V. (2013). Introduction to linear regression analysis, fifth edition. *International Statistics*, 8(2)
- Hay, S. I., Myers, M. F., Burke, D. S., Vaughn, D. W., Endy, T., Ananda, N., ... & Rogers, D. J. (2000). Etiology of interepidemic periods of mosquito-borne disease. *Proceedings of the National Academy of Sciences*, 97(16), 9335-9339.
- Jackson, M. C., Johansen, L., Furlong, C., Colson, A., & Sellers, K. F. (2010). Modelling the effect of climate change on prevalence of malaria in western Africa. *Statistica Neerlandica*, 64(4), 388-400.
- Lindsay, S. W., & Martens, W. (1998). Malaria in the African highlands: past, present and future. *Bulletin of the World Health Organization*, 76(1), 33.
- Messina, J. P., Taylor, S. M., Meshnick, S. R., Linke, A. M., Tshefu, A. K., Atua, B., ... & Emch, M. (2011). Population, behavioural and environmental drivers of malaria prevalence in the Democratic Republic of Congo. *Malaria journal*, 10, 1-11.
- Myers, R. H., Montgomery, D. C., Vining, G. G., & Robinson, S. T. J. (2012). *Generalized linear models: with applications in engineering and the sciences*. John Wiley & Sons.
- Pedro L. D. P, Ivanil S. B., & Walter C. B. (2003). The Linear Interpolation Method: A Sampling Theorem Approach., Faculdade De Engenharia El'Etrica E De Computa,C'ao, Universidade Estadual De Campinas, Cp 6101 13081-970, Campinas - SP - Brasil. Vol.14 no.4
- Shulman, C. E., Dorman, E. K., Cutts, F., Kawuondo, K., Bulmer, J. N., Peshu, N., & Marsh, K. (1999). Intermittent sulphadoxine-pyrimethamine to prevent severe anaemia secondary to malaria in pregnancy: a randomised placebo-controlled trial. *The Lancet*, 353(9153), 632-636.
- Steketee, R. W., Nahlen, B. L., Parise, M. E., & Menendez, C. (2001). The burden of malaria in pregnancy in malaria-endemic areas. *The Intolerable Burden of Malaria: A New Look at the Numbers: Supplement to Volume 64 (1) of the American Journal of Tropical Medicine and Hygiene*.
- World Health Organization. (2019). *The E-2020 initiative of 21 malaria-eliminating countries: 2019 progress report* (No. WHO/CDS/GMP/2019.07). World Health Organization.