Biotechnology

Statistical analysis investigating seasonal prevalence and forecasting malaria in Lokoja Kogi state

Ajare Emmanuel Oloruntoba[1*], Ajare Oluwayemisi Esther[3], Ajare Aduragba Oluwasegun[2] and Mohammed Danyau[2]

[1] Department of Statistics, Federal University, Lokoja, Nigeria

[2] Department of Public Health, Bill and Melinda Gates College of Health Science, Ningy, Bauch State, Nigeria

[3] National Commission for Mass Literacy, Adult and Non-Formal Education, Nigeria

Correspondence Author: Ajare Emmanuel Oloruntoba

Received 2 March 2026; Accepted 23 Apr 2026; Published 4 May 2026

Abstract

Malaria is one of the world's common and serious infection us diseases which cause at least one million deaths globally e very year. The majority of malaria occurred in the developing countries and the proportion keeps increasing annually because of dilapidated health facilities, deteriorating health system, persistent drug and insecticide resistance, climate change experience s, natural disaster. This study investigates seasonal prevalence and forecasting malaria in Lokoja Kogi state. The State Ministry of Health and its workers should carry out campaign awareness against this malaria, since the trend indicated that 0.11% and 0.51%. shows monthly decrease in overall malaria prevalence, children and adult malaria reported cases. The pregnant women generally, should be encouraged to attend Antenatal Care (ANC) since the result revealed that there was an increase of 0.82% in Malaria incidence cases. The Lokoja, Kogi State Administration should inoculate her residence and fumigate the environment at least Quarterly. The removal of blocked drainages and environmental cleanliness within the Capital City, Lokoja.

Keywords: Seasonal prevalence, Fatality rate, Healthcare, Malaria and maternal care

1. Introduction

Malaria is one of the world's common and serious infection us diseases which cause at least one million deaths globallye very year. The majority of malaria occurred in the developing countries and the proportion keeps increasing annually because of dilapidated health facilities, deteriorating health system, persistent drug and insecticide resistance, climate change experiences, natural disaster. Malaria around the world had been eradicated through the destruction of lava of anopheles mosquito, such that the plasmodium itself is no more existing in such region. But in Africa, millions of dollars anti malaria drugs are pump into Africa to cure malaria which is an endodermic problem.

Globally, Malaria is increasingly becoming a disease of serious concern to everybody because day by day, the impact of Malaria in human existence, all over the world, becomes more ravaging and damaging as a result of high morbidity and mortality experienced in different parts of the globe especially the developing countries like Nigeria. Malaria parasite has been in existence since the dawn of time.

Hippocrates, a physician born in ancient Greece, today regarded as the "father of medicine" was the first to describe the manifestation of the disease. Its association with stagnant water (breeding grounds for the Anopheles Mosquito) led the Romans to begin drainage program, the first intervention against Malaria. The first recorded treatment of Malaria dates back to 1600, when the bitter bark of Cinchona tree in Peru was used by the native Indians. (Sherman, 1998) [35]. Not until 1889 was the protozoa (single celled parasite) that cause s Malaria discovered by Alphonse Laveran and only in 1987 was the Anopheles Mosquito demonstrated to be the vector for the disease by Ronald Ross. The discovery of Ronald Ross was followed by a series of important works which not only enlarged the understanding of Malaria but also supplied useful knowledge in the combat against Malaria and prevention of Malaria. Despite initial success, there was a complete failure to eradicate Malaria in m any countries (Mills *et al*; 2018).

The world's population - are at risk of Malaria and one million people die each year as a result of malaria infection. In Nigeria, 25% of Malaria death cases occur in Lokoja Kogi State.; Particularly, 1 in 5 childhood deaths are caused by Malaria; while 1, 000 pregnant women and 8 00 infants die of Malaria annually. (Ofovwe and Erejie, 2010).

Malaria accounts for an estimated 2 to 3 million deaths annually and is also responsible for untold morbidity in approximately 300 to 500 million people annually. Susceptible groups are children and adults who never acquired immunity. (WHO, 2017).

Malaria is said to kill about one African (whether child or adult) every 15 secs and roughly 300, 000 Nigerian children annually (Salako, 1981) [32]. Malaria is responsible for over 10% of the overall African disease burden. Children under five years of age (22% of the population) and pregnant women (20% of the population) are the most vulnerable to Malaria disease (Guillet *et al*, 2018) [22].

Nigeria is known for a high prevalence of malaria and it is a leading cause of morbidity and mortality in the country

(Onwujekwe *et al*, 2000). Available records show that at least 50% of the population of Nigeria suffers from at least one episode of Malaria each year and Malaria accounts for over 45% of all out -patient visits (Ejezie *et al*, 1991).

The malaria infection is increasingly becoming a disease of serious concern to everybody and the significant impact of malaria in human existence. Malaria is a mosquito -borne disease caused by a parasite. People with malaria often experience fever, chills, and flu -like illness. Infection: -Infection is the invasion of an organism's body tissues by disease -causing agents, their multiplication, and the reaction of host tissues to the infectious agents and the toxins they produce. Infectious disease, also known as transmissible disease or communicable disease is illness resulting from an infection. Lokoja is located in central Nigeria. Lokoja, Kogi State is situated in middle belt region and was found in 1976 from part of Nasarawa, Niger, Kaduna and Kogi State. It is within the middle belt region of the country. It is administered by the Lokoja Local Government Council, headed by a Local Government Chairman elected by the Residents of the Local Government.

Forecasting: Is the process of making predictions of the future based on past and present data and most commonly by analysis of trends Mean Absolute Deviation (MAD):- The Mean Absolute Deviation expresses accuracy in the same units as the data, which helps conceptualize the amount of error. Outliers have less of an effect on MAD than on MSD. Lokoja, Kogi State becomes more ravaging and damaging as a result of high morbidity and mortality experienced in different parts of the Federation. However, the stagnant water (breeding grounds for the Anopheles mosquito) led to the research of this study; whether the inability of Government and stakeholders in the Federal Ministry of Health sector to device appropriate workable measures in the areas of technology.

The rate of malaria incidence in Lokoja associated with stagnant water led to the research whether malaria in pregnancy women, malaria in children and adult in the case study is increasing or decreasing. This study investigate seasonal prevalence and forecasting malaria in Lokoja Kogi state.

2. Literature

Malaria parasite is transmitted from one person to another through the bite of a female Anopheles Mosquito which requires blood to nurture her eggs. When Malaria parasites enter the blood stream of a person, they infect the red blood cells and destroy it. The destruction of these essential cells leads to fever and flu -like symptoms such as chills, headache, muscle aches, tired ness, nausea, vomiting, diarrhea and if not treated leads to coma and sometimes death (Thomas, 2014) [38].

The symptom of malaria infection involves sessions of fever that coincide with parasites bursting out of red blood cells, chills, sweating, headache, muscle ache, nausea, vomiting, insomnia, tastelessness, body weakness and so on. The malaria symptoms in the Lokoja, Kogi State, consist of severe anemia, fever, and convulsion, abnormal breathing, extreme weakness, hypoglycemia, circulatory collapse, edemas, septicemia, occasional kidney failure, and trauma in children. The one-fifth of patients die of severe malaria infection despite being admitted to the hospitals for treatment (Ezedinachi *et al*, 2008) [16].

It is discovered that there has been a very little change in the geographical distribution s of malicious areas but within the countries, areas of rural economic exploitation have become focus for intense malaria transmission. The malaria situation in some area councils constitutes a leading cause of poverty to the inhabitant of Lokoja, Kogi State. (Rose, 2017)

The saliva also transmits the organisms of Malaria, yellow fever, dengue, and most of the other diseases for which mosquitoes are notorious. When a mosquito punctures "bites" into the flesh, one usually feels an allergic reaction to the saliva, which causes the swelling, itching and also helps explain why some people suffer more than others when their skins are invaded. Some mosquito species are noct urnal, diurnal, or crepuscular. (Philips 2016).

More so, they also differ in their preferences for attitudes. The flight ha bits of mosquitoes depend on the species and most domestic species remain fairly close to their point of origin. The flight range for females is usually longer than that of males.

Many times wind is a factor in the dispersal or migration of mosquitoes. Most mosquitoes stay within a mile or two of their sources. However, some have been recorded as far as 75 miles from their breeding source. The length of life of the adult mosquito usually depends on several factors: temperature, humidity, sex of the mosquito and time of year. Most males live a very short time, about a week; and females live about a month depending on the above factors. (Smith *et al*,1994) [37].

Mosquito goes through four separate and distinct stages of its life cycle and they are: -Egg, Larva, Pupa, and Adult (Sherman, 1998) [35] Egg: Egg is laid one at a time and they float on the surface of the water but in the case of Culex and Culiseta species, the eggs are stuck together in rafts of a hundred or more. Anopheles and Aedes species do not make egg rafts but lay their eggs separately. Culex, Culiseta, and Anopheles lay their eggs on the water while Aedes lay their eggs on damp soil that will be flooded by water. Most eggs hatch into larvae within 48 hours. Culex Mosquitoes lay their eggs on the surface of fresh or stagnant water and the water may be in tin cans, barrels, horse troughs, ornamental ponds, swimming pools, puddles, creeks, ditches, or marshy areas. It usually lay their eggs at night and it lay a raft of eggs every third night during its life span/cycle.

Anopheles mosquitoes lay their eggs singly on the water, not in rafts while Aedes mosquitoes lay their eggs singly on damp soil. (Bruce-Chwatt, 2017) [10] Larva: The larva/larvae live in the water and come to the surface to breathe. They shed their skin four times while growing larger and after each molting, the larvae have siphon tubes for breathing and hang from the water surface. Anopheles larvae do not have a siphon and they lay parallel to the water surface. It feeds on micro -organisms and organic matter in the water and it takes larva up to four days before changes to a pupa (Sherman, 1998) [35].

Pupa: This stage is a non -feeding stage but a resting time and from this stage that mosquito turns into an adult. It takes about two days before the adult is fully developed and when development is completed, the pupa skin splits and the mosquito emerges as an adult. (Laveran, 1978) [25]

Adult: The newly emerged adult rests on the surface of the water for a short time to allow itself to dry and all its parts to harden. More so, the wings have to spread out and dry properly before it can fly. The egg, larvae and pupae stages depend on temperature and species characteristics as to how long it takes for development. For instance, Culextarsalis might go through its life cycle in 14 days at 70o F and take only 10 days at 80oF. Some species have naturally adapted to go through their entire life cycle in as little as four days or as long as one month. (Salako, 1991) [33] According to the Federal Ministry of Health (2015), Malaria is responsible for 60% of in - and out -patient visits to health facilities; 30% of childhood deaths; and 11% of maternal deaths. Furthermore, the Federal Ministry of Health (FMH) estimated a financial loss from malaria (in the form of treatment costs, prevention, loss of man -hours, etc.) to be roughly thirteen (13) m illion Naira annually. With these staggering statistics, i t is clear that health is a prerequisite for economic prosperity. The disease is directly contributing to poverty, low productivity, and reduced school attendance in Lokoja, Kogi State.

According to National Institute of Allergy and Infectious Diseases (2008), Malaria is caused by a microscopic parasite called plasmodium which comprises of four species and these parasites infecting humans to cause malaria but plasmodium falciparum is the deadly one. Plasmodium is transmitted to people by blood -through mosquitos‟ bite and is described as malaria "vector" because it spreads but doesn't cause disease.

The plasmodium has a complex life cycle involving the infection and destruction of red blood cells and the red blood cells burst, freeing the parasites to attack other red blood cells and from there the symptoms of malaria may begin to surface. Malaria may also cause by the bites of Anopheles, a dirty environment of stagnant water around the vicinity/compound.

Antimalarial drugs have been seen widespread use over the last century, including Quinine, Chloroquine, Mefloquine, Sulfadoxine -Pyrimethamine, and A modiaquine.

Misuse of these drugs, however, has led to growing resistance from malaria parasites. Over the last decade new Artemisinin - Based D rugs-Artesunate, Artemether, and Dihydroartemisinin - have become available. In an attempt to prevent resistance, these drugs are now used in combination s with drugs from a different class forming Artemisinin Combination Therapies (ACTs) (Peters, 2017) [29].

3. Methodology/Research

Sources of data

The data used for this research was collected from the Kogi State Ministry of Health Lokoja, Nigeria. In the course of this study, the researcher resorted to working with secondary data because such data were already documented for research consumption and other purposes. The researcher used secondary data because the data are readily available; hence, it saves time and resources. (Ministry of Health, 2024)

Population of the study

The population targeted for the study was all reported cases of malaria prevalence in Lokoja, Kogi State from 2020 to 2024.

Methods of data collection

For this study, the researcher consulted documented data that was collected recorded and documented by the Ministry of Health (MoH) on the cases of Malaria prevalence in Lokoja, Kogi State Capital.

- Trend or Secular Movement
- Seasonal Variation
- Cyclical Variation and
- Random or Irregular Variation

Trend: Trend is denoted by (T_t) and it is referring to the general direction in which the time plot appears to be moving. In other words, a time series is said to contain a trend if the mean of the series changes systematically with time. This systematic change may be linear, quadratic or exponential. If there is no trend, it is called a stationary series.

Seasonal variation: This seasonal variation is denoted by (S_t) and it is referred to identical patterns which the time series follow during corresponding months or quarters of success. For instance, an event likes Sallah, Christmas, Easter, marriages, and so on.

Cyclical variation: The cyclical variation is denoted by (C_t) and it is referred to as the long -term oscillation about the trend line. The oscillations are not exactly to another. For example, the business cycle represents intervals of prosperity, recession, depression, and recovery.

Irregular variation: The irregular variation is denoted by (I_t) and it is referred to as sporadic motions of a time series due to the change of an event such as war, flood, earthquake, strike, fire outbreak, etc.

Time Series Model

Multiplication model: This is the method of adjusting the corresponding quarter by a constant percentage.

$$Y_P = T_p * S_p * R_p$$

BFAST (Breaks for Additive Seasonal and Trend) is the technique used in analyzing the generality of time series data by extracting the trend and seasonal pattern during time series decomposition. Given the general time series additive model of the form of equation.

Additive model takes all other components relatively trend and seasonal component to be randomized (R_p) and the equation was expressed as

$$Y_P = T_p + S_p + R_p \quad (1)$$

The residual random consist of cyclical and irregular component.

To generate trend components using BFAST, we need a piecewise linear model approach. Suppose T_p is a piecewise linear model with an actual slope and intercept on q+1 segments broken with q breakpoints and P period; $p_1^{\neq}$,……., $p_q^{\neq}$ then T_p can takes the form as follows

$T_p = \alpha_k + \beta_k P$

Where $p_{k-1}^{\neq} < p \leq p_k^{\neq}$

and If k = 1,…..,q then $p_0^{\neq} = 0$ and $p_{q+1}^{\neq} = n$.

The slope of the change before the breakpoints while β_{k-1} and the slope of the breaks after the change breakpoints are β_k. The intercept and the slop of the linear model α_k and β_k with time period p and it will be used to derive the magnitude and direction of change.

To generate seasonal components using BFAST, we need a simple harmonic model.

Thus, S_p can be represented by a simple harmonic model with j terms; j = 12….J and time t.

$S_p = \sum_{j=1}^{J} \omega_{k,j} \text{ Sin } \frac{2\pi jt}{F} + \sigma_{K,j})$ (2)

where k = 1… q, $p_{k-1}^{\neq} < p \leq p_k^{\neq}$ and also $\omega_{k,j}$, $\sigma_{K,j}$ are the segment amplitude and F is the frequency.

To generate random components, any data that does not belong to trend nor seasonal is classified random R_p.

$$Y_P = \underbrace{\{\alpha_k + \beta_k P\}} + \underbrace{\left\{\sum_{j=1}^{J} \omega_{k,j} \text{ Sin } \left(\frac{2\pi jt}{F} + \sigma_{K,j}\right)\right\}} + \underbrace{R_p} \quad (3)$$

$Y_P = T_p + S_p + R_p$

The new technique called GFTSC considered splitting the random into cyclical components and irregular components which is an extension of BFAST. This was done through the inclusion of two new components.

To calculate cyclical components, center moving average is involved

Derivation of cyclical code, let CMA be the center moving average of t objects, then CMA can be computed as follow

$CMA = \sum_{t}^{n} \frac{Yt}{nt}$ (4)

$C_p = \frac{CMA}{\hat{CMA}}$ (5)

After extracting the trend, seasonal and cyclical components, the left out components is called irregular components, the new equation becomes

$$Y_P = \underbrace{\{\alpha_k + \beta_k P\}} + \underbrace{\{\sum_{j=1}^{J} \omega_{k,j} \text{ Sin } (\frac{2\pi jt}{F} + \sigma_{K,j})\}} + \underbrace{\{\frac{CMA}{\hat{CMA}}\}} + \underbrace{\{I_p\}} \quad (6)$$

$Y_P = T_p + S_p + C_p + I_p$

For identification of Y_P, S_p, C_p, and I_p

The Time Series Decomposition for lnOM (InOM = ln of Overall Malaria Prevalence) using Multiplicative Model

Data	Length	No. of missing value
LnOM	60	0

Fitted Trend Equation of overall Malaria prevalence in Lokoja, Kogi State, is given as $Y_t = 7.62582 - 0.00112517*t$

The above trend equation shows a monthly decrease of 0.11% in the overall malaria prevalence in Lokoja Kogi State for the period of January 2020 to December 2024.

Table 1: Seasonal indices of overall Malaria prevalence in the Lokoja Kogi State

Period (Month)	Index	Percentage (%) index	Remarks
January	1.00517	100.517	Increase by 0.517
February	1.01936	101.936	Increase by 1.936
March	1.02834	102.834	Increase by 2.834
April	1.03081	103.081	Increase by 3.081
May	1.02513	102.513	Increase by 2.513
June	1.03571	103.571	Increase by 3.571
July	1.00755	100.755	Increase by 0.755
August	0.99689	99.689	Decrease by 0.311
September	0.97962	97.962	Decrease by 2.038
October	0.98847	98.847	Decrease by 1.153
November	0.95901	95.901	Decrease by 4.099
December	0.92392	92.392	Decrease by 7.608

From table 1 above, the month of January to July experienced an increased prevalence of malaria with highest prevalence in the month of June with (3.6%) while in the month of August to December experienced decrease prevalence in malaria with lowest prevalence in the month of December (7.6%).

Table 2: Accuracy measures for malaria prevalence in the overall reported cases in Lokoja Kogi State from 2009 to 2018

Accuracy	MAPE	MAD	MSD
Measures	3.99439	0.30385	0.16201

Table 3: Forecasts of the overall malaria prevalence in Lokoja Kogi State from 2020 to 2024

Period	Forecast	Exponential of the forecast
January	7.52839	1861
February	7.63356	2067
March	7.69965	2208
April	7.71694	2247
May	7.67330	2151
June	7.75127	2325
July	7.53945	1881
August	7.45856	1735
September	7.32822	1523
October	7.39334	1626
November	7.17191	1303
December	6.90843	1001

The forecast in the table 3 above, revealed a decline in the overall malaria prevalence in Lokoja, Kogi State for the year 2025

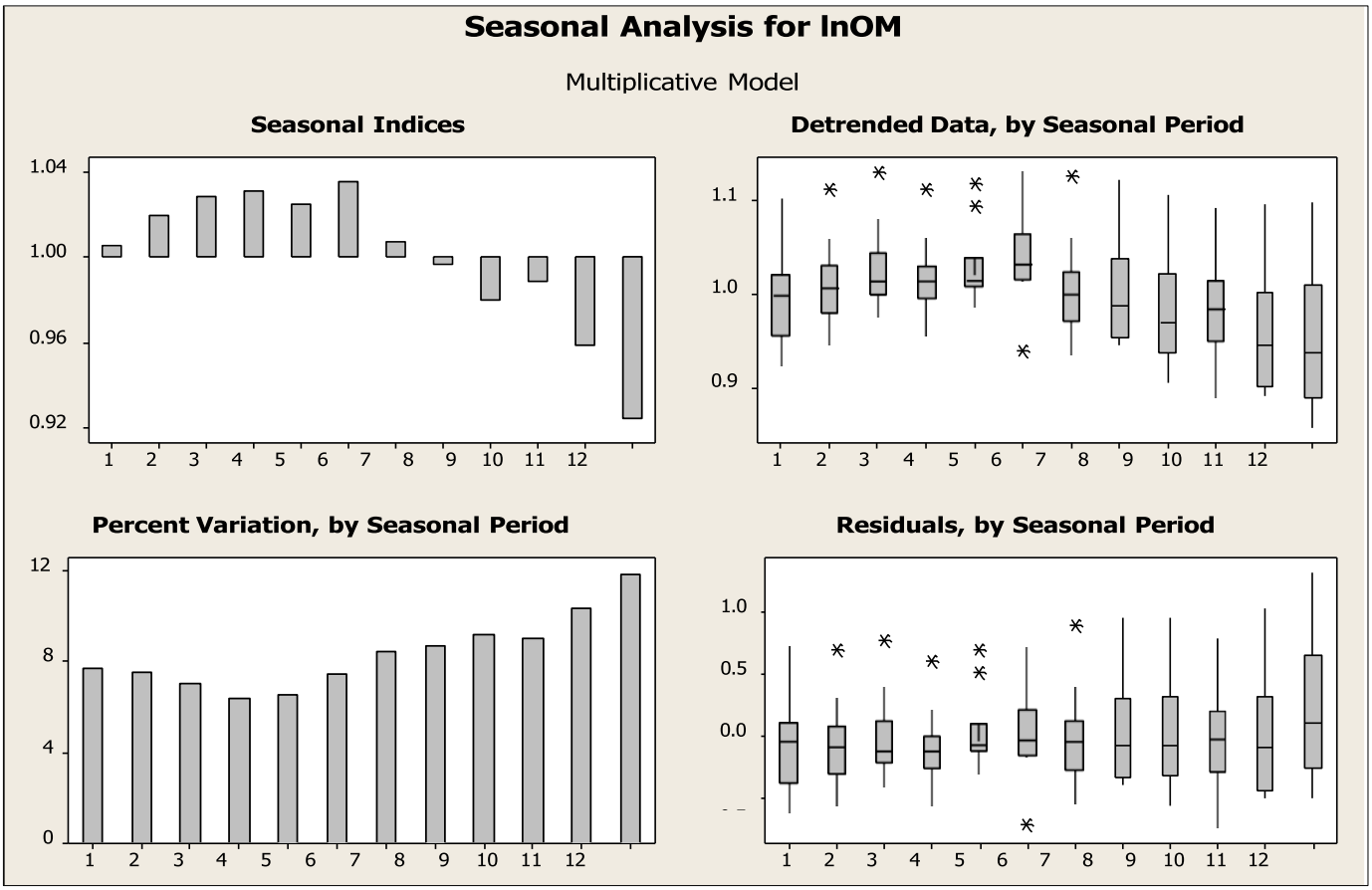

Fig 1: The Seasonal Analysis of Overall Malaria prevalence in Lokoja Kogi State, from 2009 to 2019

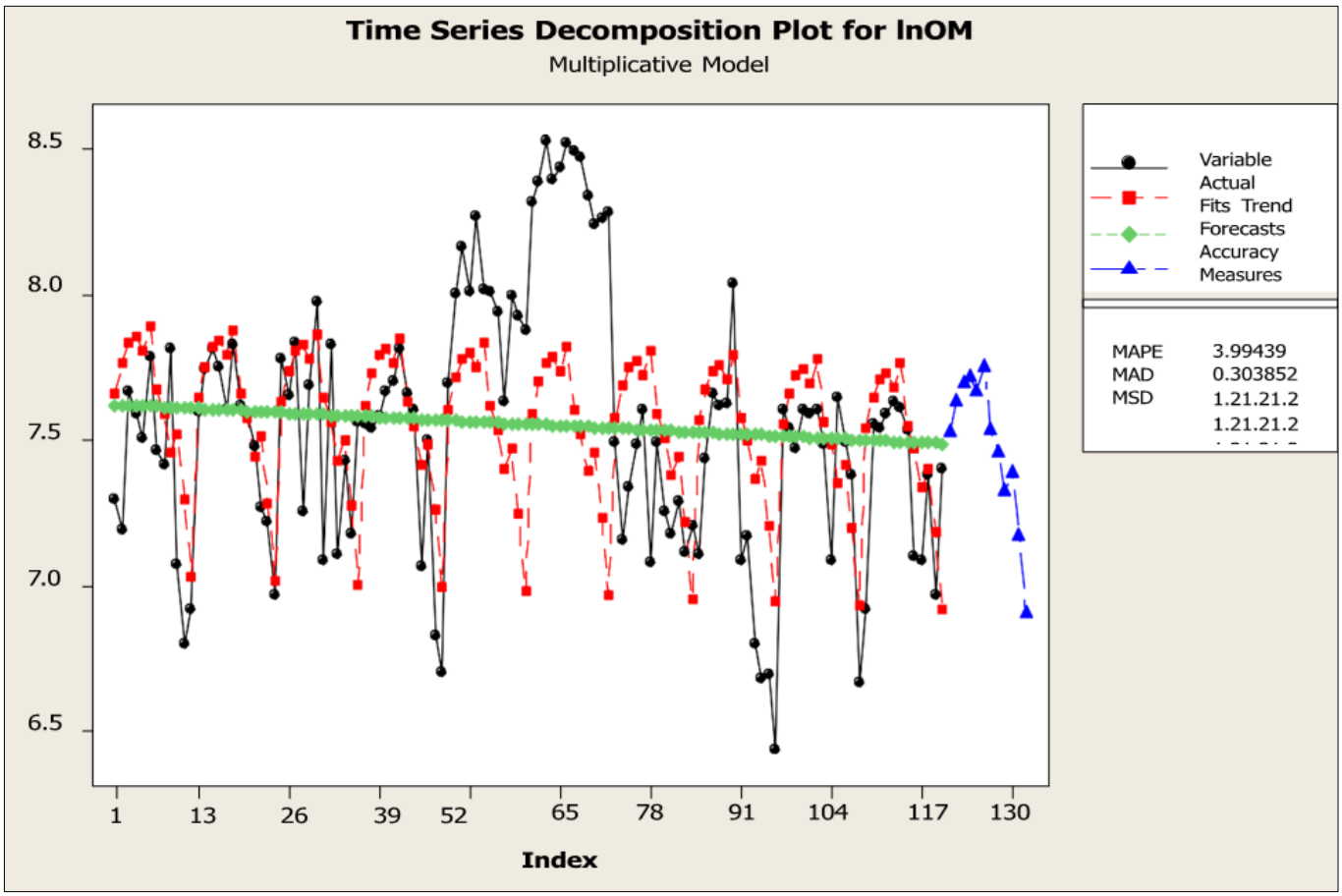

Fig 2: Summary of Time Series Decomposition of overall Malaria prevalence in, Lokoja from 2020 to 2024. The graph shows the fluctuation of malaria

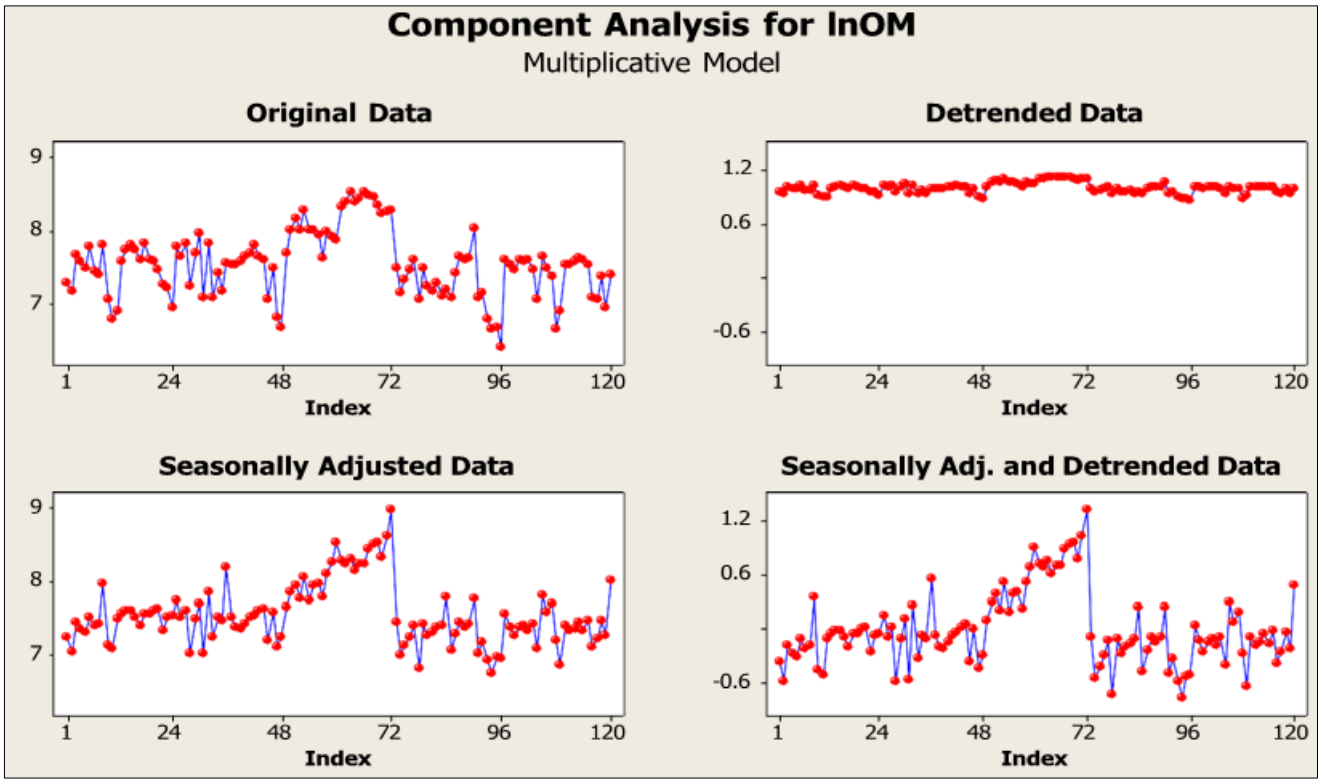

Fig 3: The Component Analysis of overall Malaria prevalence Lokoja, Kogi State from 2020 to 2024.

Table 4: Possible SARIMA models for overall Malaria prevalence in Lokoja, Kogi State from 2020 to 2024

Sarima	MSE	Remarks
$(1,1,1)\ X\ (1,1,1)_{12}$	0.0998	AR not significant MA significant and adequate
$(0,1,1)\ X\ (0,1,1)_{12}$	0.1005	MA significant and adequate

The SARIMA $(0, 1, 1)\ X\ (0, 1, 1)_{12}$ was selected as the preferred model because it has the least number of parameters which are significant in the model and also the model is adequate. Which evidence can be seen in the ACF (Autocorrelation

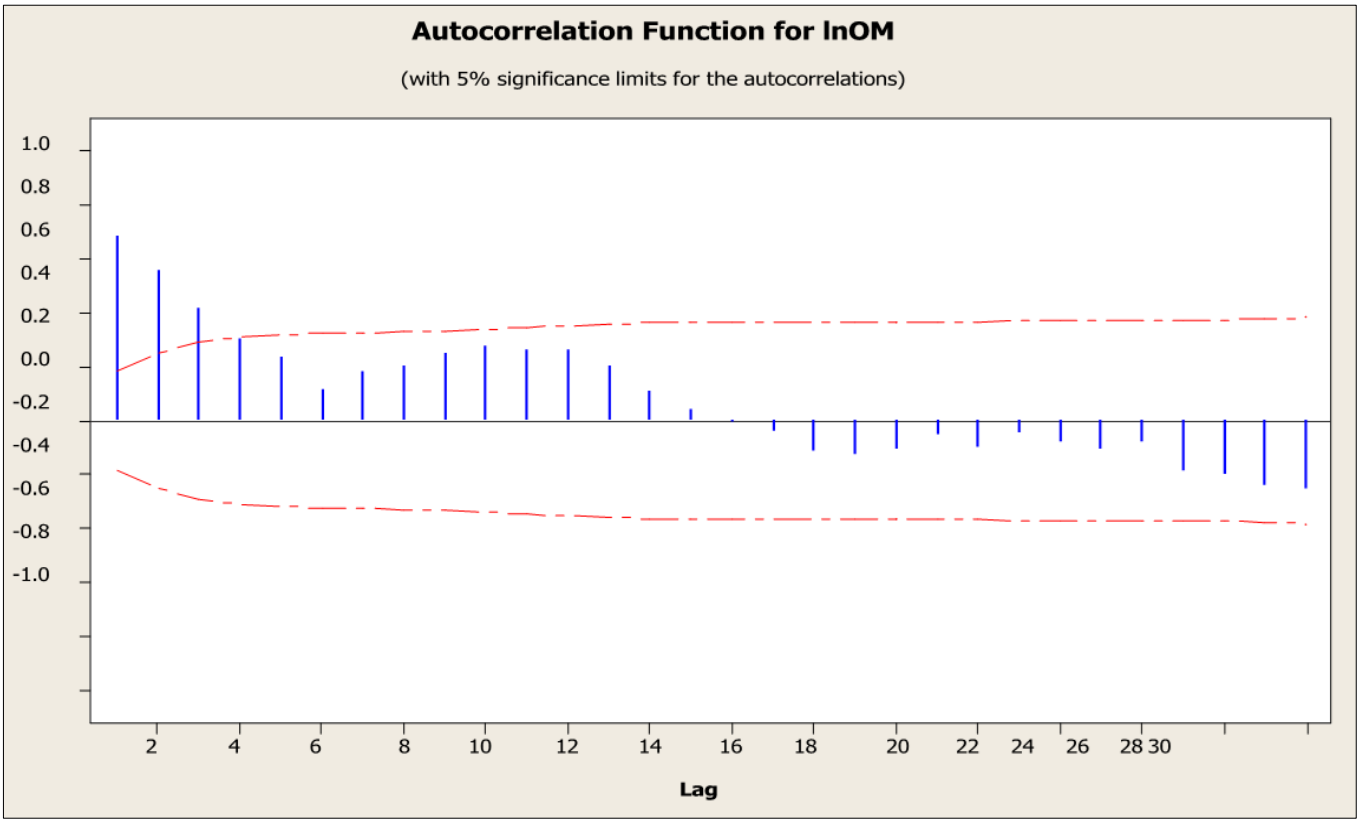

Fig 4: SARIMA MODELS using (ACF = Autocorrelation Function for Overall Malaria prevalence in Lokoja Kogi State from 2020 to 2024

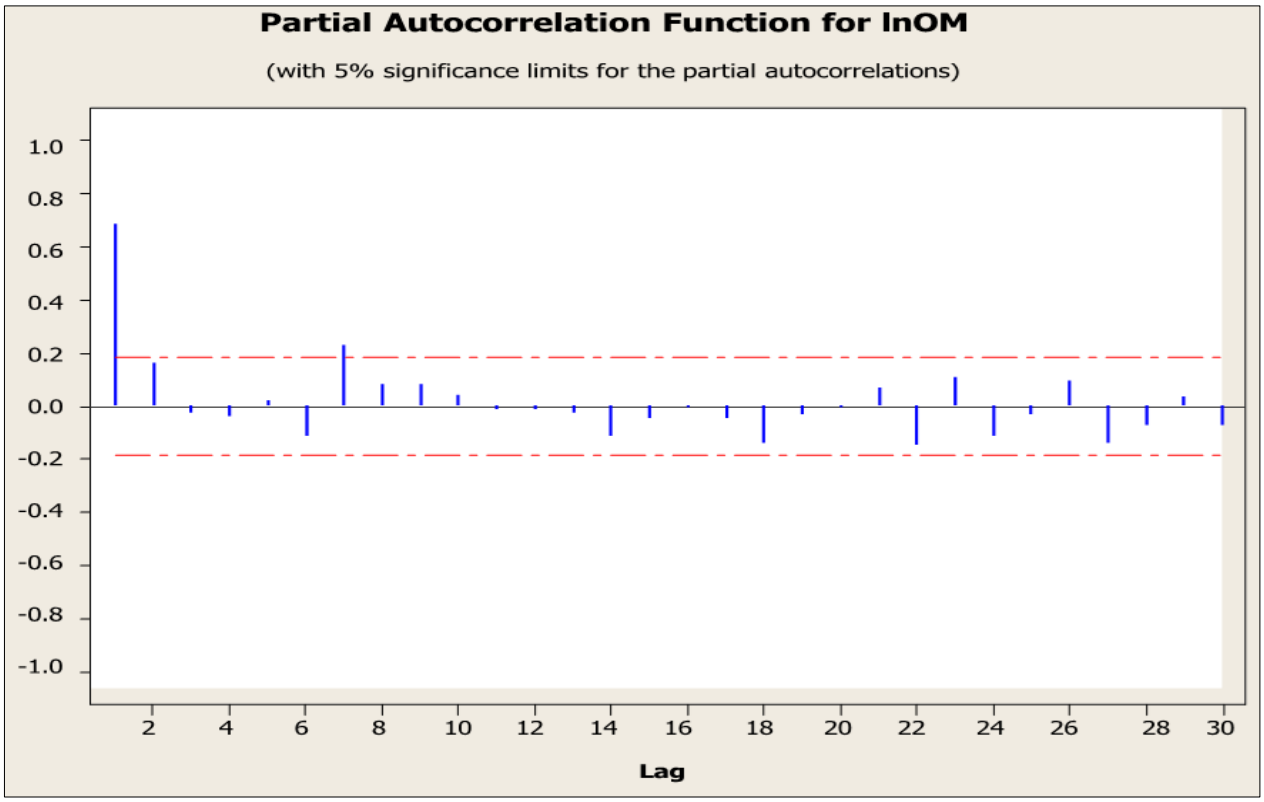

Fig 5: Sarima Models using Partial Autocorrelation Function (PACF) for Overall Malaria prevalence Lokoja Kogi State from 2020 to 2024

Table 4: SARIMA (0,1,1)x(0,1,1)$_{12}$ model for overall malaria prevalence in Lokoja Kogi State from January 2020 to December 2024

Final Estimates of Parameters				
Model type	**Coef**	**Stardard E**	**Test statistic**	***p*-value**
MA (1)	0.4998	0.0863	5.79	0.000
SMA (12)	0.8613	0.0801	10.76	0.000
Constant	-0.000919	0.003763	-0.24	0.808

Differencing: 1 regular, 1 seasonal of order 12
Number of observations: Original series 60, after differencing 47 Residuals:
SS = 10.4483 (backforecasts excluded), MS = 0.1005 DF = 44
Modified Box-Pierce (Ljung-Box) Chi-Square statistic

Lag	12	24	36	48
Chi-Square	6.9	19.7	36.6	40.9
DF	9	21	33	45
p-value	0.645	0.538	0.307	0.644

Table 5: Forecasts from SARIMA (0,1,1) x (0,1,1)$_{12}$ model for overall malaria prevalence in Lokoja Kogi State from Jan 2020 to Dec 2024

95.0 Percent				
Period	**Forecast**	**Limits**		**Exponential of the forecast**
		Lower	**Upper**	
January	7.57540	6.95403	8.19677	1950
Feb	7.67625	6.98148	8.37101	2157
Mar	7.78116	7.02004	8.54227	2396
April	7.74763	6.92551	8.56976	2317
May	7.80410	6.92518	8.68301	2451
June	7.84239	6.91015	8.77464	2546
July	7.62291	6.64022	8.60560	2045
August	7.50513	6.47446	8.53580	1817
September	7.44309	6.36658	8.51960	1708
October	7.46227	6.34179	8.58274	1741
November	7.26828	6.10550	8.43106	1435
December	7.20772	6.00412	8.41132	1350

Table 5 present the forecast from SARIMA (0,1,1) x -(0,1,1)$_{12}$, shows the highest prevalence in the month of June with (2546) while the least malaria prevalence shows in the month of December with (1350)

4. Findings and Recommendation

Findings and conclusion of this study, the research recommends that Government should:

The State Ministry of Health and its workers should carry out campaign awareness against this malaria, since the trend indicated that 0.11% and 0.51%. shows monthly decrease in overall malaria prevalence, children and adult malaria reported cases. The pregnant women generally, should be encouraged to attend Antenatal Care (ANC) since the result revealed that there was an increase of 0.82% in Malaria incidence cases. The Lokoja, Kogi State Administration should inoculate her residence and fumigate the environment at least Quarterly. The removal of blocked drainages and environmental cleanliness within the Capital City, Lokoja.

The study will make the Government introduce the usage of mosquitoes treated nets and insecticides.

This will guide the Government in formulating policies on malaria infectious control. This knowledge will guide other researchers who want to embark on further study on malaria-endemic. The study if adopted will create awareness to the general public on the control of malaria infections.

Note: Detail examination and forecast indicate no eradication of Malaria in Nigeria in the next ten years if recommendation in this paper is not fully implemented.

5. Discussion

fitted Trend Equation of overall total number of Malaria prevalence, in Lokoja Kogi State given as:

$Y_t = 7.62582 - 0.00112517*t$

The above trend equations showed a monthly decrease of 0.51% in the overall malaria incidence cases and the malaria prevalence in Lokoja Kogi State. the month of January to July experienced an increased prevalence of malaria with highest prevalence in the month of June with (3.6%) while in the month of August to December experienced decrease of malaria prevalence with lowest prevalence in the month of December (7.6%), SARIMA $(0,1,1)x(0,1,1)_{12}$ as the preferred model because it has the least number of parameters which are significant in the model and also the model is adequate as well as evidence can be seen in the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The Autocorrelation Function (ACF) plots of the transformed malaria cases of data in figure 4.1.4 showed a depict seasonality, which dies down slightly, while the Partial Autocorrelation Function (PACF) plots of the malaria cases of data in tail off after lag 1 and decays in sine-wave fashion in an initial attempt to remedy the non-stationary of the time series, and eliminate the trend and seasonality.

forecast of SARIMA $(0,1,1) \times (0,1,1)_{12}$, with the highest overall malaria prevalence in the month of June with (2546) while the least malaria prevalence in the month of December with (1350).

The Test of over dispersion was conducted and Negative Binomial Regression Model was proposed since descriptive statistic above, shows evidence of over dispersion, that is, the variances are greater than the means of malaria prevalence in Lokoja Kogi State from January, 2020 to December, 2024.

6. Conclusion

Malaria is transmitted through the bite of an infected female Anopheles mosquito, which usually feeds between sunset and sunrise. The Anopheles itself becomes infected by taking in parasites after feeding on infected human blood. The parasites then develop inside the mosquito and about a week later can be transferred to a new host when the mosquito feeds again. Young children and Pregnant Women are at the highest risk of malaria infectious and mortality. Many children experience initial malaria infection during their first two years of life, when they have not yet developed sufficient immunity, making this early year particular dangerous.

The development of predictive models is a vital part of malaria surveillance, enabling policymakers and public health workers to project the future occurrence of the disease and act proactively. Therefore, the State Ministry of Health together with the health workers should intervene in the creation of awareness of this silent killer disease. Although the model also proved that the model is adequate for forecasting of monthly reported cases of malaria infectious in Lokoja and the forecast was also found to have an oscillatory trend for some time and then remain constant for some period. Moreover, the model was found to have a possible SARIMA (0, 1, 1) (0,1, 1). Therefore, hospitals in Lokoja Kogi State should expect a reduction in the number of malaria cases in the coming years as shown on the forecast graphs.

7. Weakness and future research

This study investigates seasonal prevalence and forecasting malaria in Lokoja Kogi state, it is important to note that certain limitations may arise. These include potential biases in self-reported data, as participants may overestimate or underestimate their library usage or research productivity. Additionally, the study will focus on a single, limiting the generalizability of the findings to other institutions. This study is restricted to Lokoja. Increasing the scope and frame to extend to other institutions teaching hospitals in Nigeria can be a full study.

8. Acknowledgment

The authors thank the Federal University Lokoja (FUL) that makes resource material available to perfect this article.

References

1. Adebola PA, Okereke RW. Increasing burden of childhood severe malaria in a Nigerian tertiary hospital from 2000-2005. Unpublished research work. 2007.
2. Adenomon MO. *An Introduction to Univariate and Multiple Time Series Analysis with Examples in R*. 2016. ISBN: 978-978-947-896-5. pp.12-16.
3. Adenomon MO. *An Introduction to Univariate and Multiple Time Series Analysis with Examples in R*. 2016. ISBN: 978-978-947-896-5. pp.18-25.
4. Akaike H. A new look at the statistical model identification. IEEE Trans Automat Contr. 1974;19(6):716-723.

5. Akaike H. A new look at the statistical model identification. IEEE Trans Automat Contr. 1976;21(5):722-734.
6. Ayeni AO. Malaria morbidity in Akure, Southwest Nigeria: A temporal observation in a climate change scenario. Trends Appl Sci Res. 2018;6:488-494.
7. Baird JK, Owusu-Agyei S, Utz GC, Koram K, Barcus MJ, Jones TR, et al. Seasonal malaria attack rates in infants and young children in Northern Ghana. Silver Spring, Maryland: Naval Medical Research Center, 2002.
8. Box GEP, Jenkins GM. *Time Series Analysis: Forecasting and Control*. San Francisco: Holden-Day, 1976.
9. Box GEP, Jenkins GM, Reinsel GC. *Time Series Analysis: Forecasting and Control*. 3rd ed. Englewood Cliffs: Prentice Hall, 1994.
10. Bruce-Chwatt IJ. History of malaria from prehistory to eradication. In: Wernsdorfer W, McGregor I, editors. *Malaria: Principles and Practice of Malariology*. Edinburgh: Churchill Livingstone, 2017.
11. Cheesbrough M. *District Laboratory Practice in Tropical Countries*. Part 2. 2nd ed. Cambridge: Cambridge University Press, 2005. p.454.
12. Cheesbrough M. *District Laboratory Practice in Tropical Countries*. Part 1. 2nd ed. Cambridge: Cambridge University Press, 2006. pp.249-258.
13. Dickey DA, Fuller WA. Distribution of the estimators for autoregressive time series with a unit root. J Am Stat Assoc. 1979;74(366):427-431.
14. Dickey DA, Fuller WA. Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica. 1981;49(4):1057-1072.
15. Durueke AP. A research on the incidence, management and bionomics of malaria in children under 5 years of age in parts of Isiala Mbano L.G.A., Imo State, Nigeria. Unpublished research work. 2011.
16. Ezedinachi ENN, Alaribe AAA, Ejezie GC. The prevalence of *Salmonella* antibody among malaria patients in Calabar. J Med Lab Sci. 2008;7:34-41.
17. Federal Ministry of Health. *National Guidelines for Diagnosis and Treatment of Malaria*. Lokoja: Federal Ministry of Health, 2015.
18. Federal Ministry of Health. Malaria in Nigeria: Epidemiology and control. Niger Bull Epidemiol. 2016;1(3):1-19.
19. Federal Ministry of Health. *National Guidelines for Diagnosis and Treatment of Malaria*. Lokoja: Federal Ministry of Health, 2017.
20. Gerritsen A, Kruger P, Van der Loo M, Grobusch M. Malaria incidence in Limpopo Province, South Africa, 1998-2007. Malar J. 2013;7(1).
21. Greenwood BM, Marsh K, Snow RW. Why do some African children develop severe malaria? Parasitol Today. 1991;7(10):277-281. doi:10.1016/0169-4758(91)90096-7.
22. Guillett A, Lubell Y, Hanson K. Malaria eradication: The economic, financial and institutional challenge. Malar J. 2008;7(Suppl 1):S11.
23. Henderson DA. Lessons from the eradication campaigns. Vaccine. 1999;17(Suppl 3):S53-S55.
24. Korenromp E, Kiniboro B, World Health Organization. *Forecasting Malaria Incidence Estimates at Burundi Country Level for the Year 1997-2009*. Draft report. World Health Organization, 2007.
25. Laveran CLA. A newly discovered parasite in the blood of patients suffering from malaria. In: Kean BH, Mott KE, Russell AJ, editors. *Tropical Medicine and Parasitology: Classic Investigations*. Vol. 1. 1st ed. Ithaca, New York: Cornell University Press, 1978.
26. National Bureau of Statistics. *Annual Abstract of Statistics*. Abuja: Federal Republic of Nigeria, 2018. p.88.
27. National Institute of Allergy and Infectious Diseases. *Understanding Malaria: Fighting an Ancient Scourge*. NIH Publication No. 07-7139. Bethesda: NIAID, 2008.
28. Nwankwo BO, Okafor OJ. Effectiveness of insecticide-treated bed nets in malaria prevention among children aged 6 months to 5 years in a rural community in Imo State, Nigeria. Int J Trop Med. 2009;4:41-49.
29. Peters W. *Chemotherapy and Drug Resistance in Malaria*. London: Academic Press, 2017.
30. Phillips RS. Current status of malaria and potential for control. Clin Microbiol Rev. 2001;14(1):208-226.
31. Ross R. The discovery that mosquitoes transmit malaria parasites. Lancet. 2017;11:42-48.
32. Salako AH, Yekutiel P. Lessons from the big eradication campaign. World Health Forum. 1981;2:465-490.
33. Salako LA. Forms of malaria treatment. World Health Organization Magazine. 1991;(September-October):19-20.
34. Salako IA, Ajayi FO, Sowunmi A, Walker O. Malaria in Nigeria: A revisit. Am J Trop Med Parasitol. 1990;84:2-11.
35. Sherman IW. A brief history of malaria and discovery of the parasite's life cycle. In: Sherman IW, editor. *Malaria: Parasite Biology, Pathogenesis and Protection*. Washington, DC: ASM Press, 1998.
36. Shittu OI, Yaya OS. *An Introduction to Time Series Analysis*. 2016. ISBN: 978-240-083. pp.263-265.
37. Smith T, Schellenberg J, Hayes R. Attributable fraction estimates and case definitions for malaria in endemic areas. Stat Med. 1994;13:2345-2358.
38. Thomas LO. *A Comprehensive Review of Malaria with an Emphasis on Plasmodium Resistance* [dissertation]. University of Mississippi, 2014.
39. Wenceslaus LK. Roll Back Malaria in sub-Saharan Africa. Bull World Health Organ. 2000;78(12):452-453.
40. Wenceslaus LK. Roll Back Malaria in sub-Saharan Africa. Round table discussion. Bull World Health Organ. 2000;78(2):541.
41. World Health Organization. *World Health Report: Fighting Disease, Fostering Development*. Geneva: World Health Organization, 2000.
42. World Health Organization. *World Malaria Report 2013*. Geneva: World Health Organization, 2013. ISBN: 9789241564694.

43. World Health Organization. *Fact Sheet on the World Malaria Report 2013*. Geneva: World Health Organization, 2014.
44. World Health Organization. *Global Malaria Disease Surveillance for Malaria Control: An Operational Manual*. Geneva: World Health Organization, 2017. ISBN: 9789241503341.
45. World Health Organization. *Malaria: A Manual for Community Health Workers*. Geneva: World Health Organization, 2011. p.26.
46. Yeshiwondim AK, Gopal S, Hailemariam AT, Dengela DO, Patel HP. Spatial analysis of malaria incidence at the village level in areas with unstable transmission in Ethiopia. Int J Health Geogr. 2009;8:5.