Introduction

Malaria is a significant cause of morbidity and mortality worldwide.\(^1\)\(^3\) Through a combination of preventive efforts, there has been a global decline in the burden of malaria from 251 million cases worldwide in 2010 to 228 million cases in 2018, and the global mortality rate associated with the disease reduced by 55 per 100,000 people between 2010 and 2017.\(^4\) However, despite the global decline in malaria incidence and mortality, sub-Saharan Africa still accounts for 80% of the global malaria burden, out of which Nigeria, the most populous country in the region, contributed 25%, the highest prevalence in the region.\(^2\) The 2015 Malaria Indicators Survey revealed that malaria parasite prevalence is still high.\(^6\) The high prevalence in Nigeria is not surprising, as Nigeria is a country of tropical rain forest and its environment facilitates breeding sites for malaria vectors.\(^7\) Thus, malaria is endemic in Nigeria with year-round transmission, and pregnant women are one of the groups most vulnerable to the disease.\(^8\)

Analyses of case-based surveillance data on malaria in pregnancy in Plateau State, Nigeria 2013–2017

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Abstract

Background: Malaria in pregnancy accounts for 11% of maternal death in Nigeria. Plateau State has a low uptake of intermittent preventive treatment of malaria among women attending antenatal care.

Objectives: This study examined the trend and made projections of reported cases of malaria in pregnancy in Plateau State.

Methods: Data were extracted from the state disease surveillance system from January 2013 to December 2017. Reported cases of malaria in pregnancy within the 5 years under investigation were retrieved, merged and sorted by month of reporting and Local Government Area (LGA). Prevalence was calculated yearly for each LGA in Plateau State using Geographic Information System. Seasonal variation and projection were based on a multiplicative time series model.

Results: In total, 62,997 cases of malaria in pregnancy were retrieved. Prevalence was 6.9% in 2013 and increased to 15.1% in 2017. Higher prevalence was observed in Wase, Kanam and Shendam LGAs. A cyclical trend with highest number of malaria in pregnancy cases was found within the third quarter of all the years. Within the 5 years, there was higher seasonal variation for quarters three (1.209834) and one (1.099711). The highest number of cases of malaria in pregnancy was likely to occur in the third quarter, while the least was found in the second quarter. The projected numbers of malaria in pregnancy cases are 20,121, 22,593 and 25,064 for year 2018, 2019 and 2020, respectively, and the highest number of cases occurs in the third quarter.

Conclusion: Malaria in pregnancy follows an increasing trend in Plateau State, with greatest severity in the third quarter of the year. An effective intervention strategy against malaria among pregnant women is advocated.

Keywords

Malaria in pregnancy, trend analysis, surveillance system, Plateau State
Literature showed that an estimated 125 million women become pregnant every year in malaria-endemic regions, with more than 85 million at risk of malaria. All pregnant women are not equally susceptible to malaria; the susceptibility and severity of pregnant women to malaria is attributable to varying factors which include immunological and humoral changes, parity, maternal age, gestational age and intensity of transmission. Malaria in pregnancy often leads to clinical complications with attendant effects such as low birth weight, abortion, premature delivery and maternal death. Malaria in pregnancy is responsible for 5% of maternal anemia and 11% of maternal mortality in Nigeria. Furthermore, as well as the direct health impacts of malaria, there are also severe socioeconomic burdens on individuals, family, communities and the country, with huge resources lost to malaria yearly in the form of treatment costs, prevention efforts, loss of work time, etc.

The high prevalence of malaria in Nigeria motivated the government to institute the National Malaria Control Strategic Plan, whose aim is to reduce the malaria burden to pre-elimination levels and bring malaria-related mortalities to zero. This includes addressing national health and development priorities including the Roll Back Malaria goals, the Millennium Development Goals and Sustainable Development Goals. Prevention and treatment of malaria in pregnancy was included as one of the approaches to the implementation and actualization of this agenda. In addition, adoption of prevention of malaria in pregnancy interventions using long-lasting insecticide-treated nets (LLITNs), intermittent preventive treatment of malaria in pregnancy with sulfadoxine-pyrimethamine (IPTp-SP), and case management following laboratory diagnosis is in line with the National Malaria Strategic Plan and the global action for a malaria-free world.

Therefore this study was conceptualized to monitor the prevalence of malaria in pregnancy and make a projection for the years ahead using Plateau State malaria case-based surveillance data. The analysis of malaria in pregnancy case-based surveillance will provide an insight into the epidemiology of malaria in pregnancy in Plateau State. It will also help in monitoring the impact of the preventive practices with respect to malaria in pregnancy and the strength of the surveillance system within the State.

Methods

Study setting

This study was conducted in Plateau State, north central Nigeria. The State is located within a tropical zone with high altitude, giving it a near temperate-like climate with average daily temperature of 23°C. Plateau State has two seasons: the wet season (lasting between April and October) and the dry season. The highest rainfall occurs during the wet season of the year, and mean annual rainfall is 1280 mm. The low average temperature within the State and annual rainfall is led to a reduced incidence of some tropical diseases, including malaria, compared with other States in Nigeria. Plateau State has 17 Local Government Areas (LGAs) and 1024 health facilities. The projected population of pregnant women according to the State Ministry of Health was 213,052 in 2017. The State participates in the Nigeria disease surveillance system which is based on the Integrated Disease Surveillance and Response (IDSR) system. All the public health facilities in the State report selected diseases (including malaria) through this system. The summary reports are submitted by the health facilities through the LGAs to the database on monthly basis.

Study design and population

This was a secondary data analysis of reported cases of malaria in pregnancy extracted from the IDSR database from January 2013 to December 2017 in Plateau State. The disease surveillance system is an information-based activity including the collection, analysis, and interpretation of data to monitor public health control and prevention activities. The outbreak of yellow fever during the period 1986–87 which led to the death of many people motivated the introduction of disease surveillance and notification in Nigeria. At the onset of its creation, surveillance and notification of diseases involved prompt reporting of epidemic-prone diseases targeted for eradication, including malaria in pregnancy, and monthly notification of other diseases. Malaria in pregnancy is the diagnosis of malaria which is made by either microscopy, rapid diagnostic test kit or by clinical diagnosis by a physician in a pregnant woman. The timeliness (interval between the identification of malaria in pregnancy cases by the reporting health facilities and reporting to disease surveillance unit) and completeness (percentage of all expected data reports that were submitted to the public health surveillance system) of IDSR data of the State was on average 92.2% and 92.5%, respectively, for the 5-year period under study.

Data processing and analysis

All reported cases of malaria in pregnancy in the IDSR database (2013–2017) were retrieved. The data were merged and sorted by month of reporting and LGAs. The period prevalence was calculated for the study population and the distribution of the reported cases across the LGAs presented in maps. The denominator for the period prevalence was computed using information on the proportion of pregnant women in Plateau State who attended antenatal care (ANC) and those who accessed ANC services at a public health facility. The computation produced the proportion of pregnant women attending public health facilities in Plateau State (51.2%).

The pattern of malaria cases obtained for a period of 5 years (2013–2017) was modeled by aggregating the monthly data into four quarters in a year for clearer presentation. These were January–March, April–June, July–September and October–December. As a form of evaluation of the data in order to establish seasonality in the pattern, the original data were plotted (Figure 1) and the pattern suggests a multiplicative time series model. The autocorrelation of the quarterly data was therefore plotted using a correlogram to check if the time series is stationary or not. This involved the plot of autocorrelation coefficient sample against lag k, as shown in Figure 2, and this presents the degree of similarity between a given time series and a lagged version of itself over successive time intervals. Thereafter, the quarterly data were
decomposed because the parameters explaining the data remain constant over time. This is with the view to re-classify the data into several factors that can lead to variation in the number of cases of malaria. The factors are: the trend (TRt), seasonal variation (SNt), cyclical variation (CLt), and irregular variation (IRt), and their estimates were used to examine the time series. To achieve this, the centered moving average (CMAt) was computed as:

\[ y_t = \text{CMA}_t = y_t - \frac{\sum_{i=0}^{L-1} y_{t-i}}{L} \]

where \( L \) is the number of seasons in a year. Then, the estimate of \( \text{CMA}_t \) was used to obtain the average \( \overline{SN_t} \) for each of the quarter and normalized using a constant \( L \) as shown in the following:

\[ \frac{\sum_{i=0}^{L-1} \overline{SN_t}}{L} = \frac{4}{4.03} = 0.9926 \]

Thus, \( SN_t = 0.9926 \times \overline{SN_t} \).

To remove the seasonality in the data so that a better estimate of the trend (\( \text{T}_{\text{R}}t \)) can be provided, we deseasonalize the data by estimating the cases of malaria in pregnancy in time period \( t \) using \( d_t = y_t / SN_t \). Then, least square method was used to fit a regression model \( TR_t = \beta_0 + \beta_1 t \). The constant parameters \( \beta_0 \) and \( \beta_1 \) were used to determine the estimated number of cases of malaria in pregnancy (\( \hat{y}_t \)) as:

\[ \hat{y}_t = SN_t \times TR_t \]

The projection for quarterly cases of malaria in pregnancy for years 2018, 2019, and 2020 was based on \( \hat{y}_t \).

**Results**

A total of 62,997 cases of malaria in pregnancy was reviewed between 2013 and 2017, 6745 in 2013, 11,841 in 2014, 13,322 in 2015, 14,649 in 2016, and 16,440 in 2017. In Figure 1, the data show that monthly variation existed in the cases of malaria in pregnancy and the pattern indicates an increasing trend. The trend line shows that the rate of increase of malaria in pregnancy cases from January 2013 to December 2017 was 15.6, and that 39.4% of variation in the pattern of malaria in pregnancy cases can only be explained by time. Year 2017 had the highest number of malaria in pregnancy cases.
In Figure 2, the error terms in the data were positively auto-correlated because in most situations as observed in the figure, a positive error term in time period $t$ produced another positive error term in time period $t+k$, and the negative error terms produced negative error terms. The shape of the figure is an indication that positive autocorrelation in the error terms will likely produce a cyclical pattern from 2013 to 2017.

On yearly basis, the period prevalence of malaria in pregnancy increases throughout the study period. It increased consistently from 6.9% in 2013 to 15.1% in 2017 (Figure 3).

The highest prevalence of malaria in pregnancy across the study area was seen in Shendam LGA through the 5 years, with Wase Kanam LGA showing increasing prevalence from 2014 to 2015 but a reduction in prevalence was observed in the year 2017. The lowest prevalence over the 5-year period was seen in Jos East (Figure 4).

The methods involved in the determination of trend line ($\hat{\gamma}_t$) are shown in Table 1.

Table 2 provides information on how the seasonal variation of malaria in pregnancy for each quarter of all the years under investigation was computed. In the years under review, the data showed higher seasonal variation for third ($1.209834$) and first ($1.099711$) quarters compared with second ($0.895193$) and fourth ($0.872278$) quarters. Thus, the positive and negative effect of quarterly variation on the number of reported cases of malaria in pregnancy will be most in quarter 3 and quarter 4 of each year, respectively.

The line charts as shown in Figure 5 present the observed and estimated number of reported cases of malaria in pregnancy. To some extent, the estimate provided a smoothed version of the observed values and displayed a clear and regular cyclical variation in the cases of malaria in pregnancy. However, the two charts show that the cases of malaria in pregnancy might be on the increase in the years ahead.

The projected number of reported cases of malaria in pregnancy for years 2018, 2019, and 2020 are shown in Figure 6. In the figure, the data showed that highest number of cases is likely to occur in the third quarter (July–September) of the years, while the lowest may be found in the second quarter. In the years ahead (beyond 2017), the data also show that malaria in pregnancy cases will be on the increase in every quarter of the year and also at the aggregate level. The projected number of malaria in pregnancy cases are 20,121, 22,593 and 25,064 for the year 2018, 2019 and 2020, respectively.

**Discussion**

Despite the global decrease in the burden of malaria there is still a heavy burden of the disease in some regions, especially among pregnant women in developing countries like Nigeria. Malaria is endemic in Nigeria. Despite the variation in the prevalence of malaria across the 36 States in Nigeria, the prevalence remains high in each of the States and pregnant women are one of the high-risk groups.$^{15,17}$ Therefore, this study involved an analysis of case-based facility-reported surveillance data of malaria among pregnant women in Plateau State from 2013 to 2017. We examined the period prevalence of malaria in pregnancy within the period of investigation, established the presence of trends and seasonality in occurrence of malaria in pregnancy as reported in the surveillance system, and put forward forecasts with regards to the estimated number of cases of malaria in pregnancy for the years 2018, 2019, and 2020.

Increasing period prevalence of malaria among pregnant women in Plateau State was observed within the 5 years under study, and variation existed across the LGAs in the State. Higher prevalence of malaria was seen in LGAs with higher average annual temperature as compared with LGAs with lower average annual temperatures. The proximity to either temperate or tropical climate is likely to be a possible explanation for disparities in the number of cases of malaria in pregnancy across the LGAs in Plateau State as documented in the disease surveillance system. Similar patterns of malaria in pregnancy observed in this study had been previously established by previous studies in Nigeria and equally reported for other diseases.$^{23-25}$ The increasing prevalence of cases of malaria in pregnancy between 2013 and 2017 points to the weakness in the implementation of malaria reduction strategies instituted by the Nigerian government.$^{17,18,25}$

The time series model of the malaria in pregnancy cases in Plateau State revealed that seasonal variation existed in the data and the pattern was found to be cyclical. The cases of malaria in pregnancy are likely to occur mostly in the third quarter (July–September) of the year, and the pattern was

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**Figure 3.** Period prevalence of malaria in pregnancy in Plateau State 2013–2017.

![Figure 3](https://example.com/figure3.png)
Figure 4. Map showing the prevalence of malaria in pregnancy in Plateau State by LGA 2013–2017.

Table 1. Estimating the trend line and seasonal variation in the number of malaria in pregnancy cases in Plateau State, Nigeria, 2013–2017.

| Year | Qtr | t  | y_t | CMA_t | y_t / CMA_t | SN_t | d_t | TR_t | \( \hat{y}_t \) |
|------|-----|----|-----|-------|-------------|------|-----|------|------------|
| 2013 | Q1  | 1  | 1555| –     | –           | 1.099711 | 1414.008| 1684.04| 1851.96    |
|      | Q2  | 2  | 1699| 1951.00 | 0.871       | 0.895193 | 1897.915| 1835.58| 1643.20    |
|      | Q3  | 3  | 2599| 1730.00 | 1.502       | 1.209834 | 2148.229| 1987.12| 2404.09    |
|      | Q4  | 4  | 892 | 2107.67 | 0.423       | 0.872278 | 1022.610| 2138.66| 1865.51    |
| 2014 | Q1  | 5  | 2832| 1880.00 | 1.506       | 1.099711 | 2575.222| 2290.20| 2518.56    |
|      | Q2  | 6  | 1916| 3033.00 | 0.632       | 0.895193 | 2140.334| 2441.74| 2185.83    |
|      | Q3  | 7  | 4351| 3003.00 | 1.449       | 1.209834 | 3596.361| 2593.28| 3137.44    |
|      | Q4  | 8  | 2742| 3298.33 | 0.831       | 0.872278 | 3143.493| 2744.82| 2394.25    |
| 2015 | Q1  | 9  | 2802| 2754.33 | 1.017       | 1.099711 | 2547.942| 2896.36| 3185.16    |
|      | Q2  | 10 | 2719| 3143.33 | 0.864       | 0.895193 | 3037.334| 3047.90| 2728.46    |
|      | Q3  | 11 | 3915| 3506.67 | 1.116       | 1.209834 | 3235.981| 3199.44| 3870.79    |
|      | Q4  | 12 | 3886| 3622.67 | 1.073       | 0.872278 | 4455.002| 3350.98| 2922.99    |

(Continued)
also seen in the 3-year projection. This is expected, as the period falls within the time that the highest rainfall is being experienced in Plateau State.\textsuperscript{19,23,26} The rainy season has been consistently reported in the literature as the breeding season for the mosquito, the main vector of malaria.\textsuperscript{23,26} Studies previously conducted in Nigeria corroborate our finding. After decomposition of the data into the time series component, the model has evidenced that cases of malaria in pregnancy follow an increasing trend in Plateau State within the 5 years under review, and the projection shows that this

Table 1. (Continued)

| Year | Qtr | t  | \( y_t \) | \( CMA_t \) | \( \frac{y_t}{CMA_t} \) | \( SN_t \) | \( d_t \) | \( TR_t \) | \( \hat{y}_t \) |
|------|-----|----|---------|---------|-----------------|----------|-------|--------|--------|
| 2016 | Q1  | 13 | 3067    | 3556.67 | 0.862           | 1.099711 | 2788.915 | 3502.52 | 3851.76|
|      | Q2  | 14 | 3717    | 3387.67 | 1.097           | 0.895193 | 4152.177 | 3654.06 | 3271.09|
|      | Q3  | 14 | 3379    | 3860.67 | 0.875           | 1.209834 | 2792.945 | 3805.60 | 4604.14|
|      | Q4  | 16 | 4486    | 3976.33 | 1.128           | 0.872278 | 5142.856 | 3957.14 | 3451.73|
| 2017 | Q1  | 17 | 4064    | 4185.00 | 0.971           | 1.099711 | 3695.516 | 4186.88 | 4518.36|
|      | Q2  | 18 | 4005    | 4132.00 | 0.969           | 0.895193 | 4473.896 | 4260.22 | 3813.72|
|      | Q3  | 19 | 4327    | 4125.33 | 1.049           | 1.209834 | 3576.524 | 4411.76 | 5337.50|
|      | Q4  | 20 | 4044    | –       | –               | 0.872278 | 4636.137 | 4563.30 | 3980.47|

Table 2. Estimating the quarterly adjustment factor (\( SN_t \)) using the decomposed observations (\( \frac{y_t}{CMA_t} \)).

| Quarter | 2013 | 2014 | 2015 | 2016 | 2017 | \( SN_t \) | \( SN_t \) |
|---------|------|------|------|------|------|----------|----------|
| Quarter 1 | –    | 1.506| 1.017| 0.862| 0.971| 1.089    | 1.099711 |
| Quarter 2 | 0.871| 0.632| 0.864| 1.097| 0.969| 0.887    | 0.895193 |
| Quarter 3 | 1.502| 1.449| 1.116| 0.875| 1.049| 1.198    | 1.209834 |
| Quarter 4 | 0.423| 0.831| 1.073| 1.128| –    | 0.864    | 0.872278 |

Figure 5. The line chart of the observed and estimated number of reported malaria in pregnancy cases in Plateau State,\ Nigeria,\ 2013–2017.

Figure 6. Multiple bar chart of the quarterly display of the predicted number of malaria in pregnancy cases for the period 2018–2020.
trend will persist to the year 2020, despite the fact that malaria-specific preventive measures have been put in place to control the disease in pregnancy, such as the use of LLITNs and at least one dose of IPTp. It is worrisome that the prevalence of malaria in pregnancy may likely be on the increase in the 3 years following the review period. It is therefore necessary to examine the possible reasons for this trend in Plateau despite reports of distribution of effective interventions. Thus, there is the need to study the level of utilization, compliance to guidelines and general attitude toward the malaria-preventive interventions.

The main limitation of this study is that cases reported were healthcare facilities-based, with reporting facilities being government owned; therefore the study failed to capture data for pregnant women who went to private health facilities or those who did not access ANC. To account for this limitation, an estimate of only women who attended ANC in a public health facility in Plateau State was used as the denominator for the estimation of period prevalence of malaria in pregnancy.

Conclusion

Malaria in pregnancy remains a major public health challenge in Plateau State, with a projected increase in the number of cases. The trend has shown a progressive increase despite various interventions. Seasonal variations in the first and third quarter indicate a significant rise in reported cases of malaria in pregnancy. Preventive and control measures need to be intensified and strengthened, with focused health education on climatic changes.

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Authors’ contributions

OI conceptualized, acquired the data, conducted the analysis and wrote the draft manuscript; ASA conducted data analysis and interpretation, substantially revised the draft manuscript; CDU conducted data interpretation and substantially revised the draft manuscript; EAB, AAG, JJC, TD and IOA substantially revised the draft manuscript. All authors read and approved the final manuscript.

Availability of data and material

The data associated with this work is available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The ethical approval and permission was obtained from Plateau State Ministry of Health Ethical Committee.

Informed Consent

Data were retrieved with permission and approval from the Plateau State Ministry of Health.

Consent for publication

Not Applicable

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Not Applicable

Conflict of interest

The authors have no conflict of interest to declare.

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