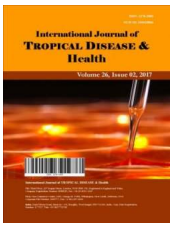

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Aspects of Climatic and Socioeconomic Parameters and Malaria Prevalence; Evidence from Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors designed the study, performed the statistical analysis, wrote the protocol, and wrote the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: Against the background that most disease eradication drives dwell more on controlling the proximal causes of diseases and the development of innovative measures for diseases treatment, this study investigates the impact of climatic parameters and the population's socioeconomic conditions on disease prevalence on the premise that these conditions promote the preponderance of the proximal causes.
Study Design: The study employed a quantitative research design of the correlational type.
Place and Duration of Study: Department of Urban and Regional Planning, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, 2015 – 2016.
Methods: The study assesses the temporal patterns and contributions of rainfall and temperature and four socioeconomic indices on malaria prevalence in Nigeria between 1985 and 2014 using Standard Deviation, Kurtosis, Pearson Product Moment Correlation and Multiple Regression statistical techniques.
Results: The results show a minimal but steady increase in malaria prevalence while changes in

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the climatic parameters and socioeconomic conditions in the period reviewed accounted for 78.6% of the variations in malaria prevalence (R^2 = .786, P < .001). The regression equation was used to project the incidence of malaria in the study area from 310 cases per 1,000 Population in 2016 to 366 cases per 1,000 Population in 2050.

Conclusion: The paper recommends that to achieve noticeable improvements in malaria eradication, greater attention should be paid to improving the socioeconomic conditions of the population as these have implications for their susceptibility to ill health and also affect their adaptation to climate change.

Keywords: Climatic parameters; socioeconomic conditions; health and disease; malaria; temporal patterns; Nigeria.

1. INTRODUCTION

Disease, a deviation from biomedical standards and normal conditions, [1] manifesting as a result of the presence of pathology in any part of the body or bodily inactivity due to an injury, [2] thereby causing health impairments through a reduction in an individual's functional ability, [3] has a variety of causal agents. While most of the causes are proximal - mosquito bites and malaria, contaminated water and diarrhea, for instance, conditions of living and in the living environment contribute largely to the prevalence of these proximal causes and make the individual become susceptible to diseases. Such conditions include climatic parameters, especially rainfall and temperature, residential habitat quality, nutritional pattern and quality of diets, literacy, and lifestyles among others. These disease-promoting conditions are consequent on climate as well as the variability of its elements, and the socioeconomic status of the individual.

This study investigates the impacts of the changes in climatic parameters and socioeconomic conditions on disease prevalence in Nigeria using malaria as a case study. Malaria is a leading cause of mortality in Nigeria with over 225,000 deaths annually from an estimated 100 million cases [4]. The Nigerian National Malaria Control Programme (NMCP) puts Nigeria's annual economic loss to Malaria at an estimated $1billion in the form of treatment costs, prevention, and loss of man-hour among others [5-6]. Climate change causes an increase in temperature, rainfall, and humidity thereby increasing the reproduction capacities of mosquitoes (malaria vectors) and results in an increase in malaria transmission [7-11]. Malaria has also been shown to be a disease of poverty, [12-14] as only 0.2% of global malaria deaths are found in the world's richest population quintile while 57.9% of global malaria deaths are concentrated among the world's poorest population quintile [15].

In answering the research question on what the individual and joint contributions of variations in climatic and socioeconomic conditions on malaria prevalence in the study area are, this study provides another vista to research on malaria eradication and prevention in Nigeria. At present, the crux of the national policy on malaria centers around treatment administration and provision of insecticide-treated nets for households to prevent exposure and transmission. This study, therefore, aligns with the United Nations Post-2015 Development Agenda that recognizes the need to address the social, economic and environmental determinants of health and their interrelationships and not just the proximal causes of illness and diseases for the achievement of health-related Sustainable Development Goals (SDGs) [16]. Based on the findings, the study attempts a projection of the future pattern of malaria prevalence to assist in planning and instituting preventive measures, particularly with respect to the disease-promoting climatic and socioeconomic conditions. This is more so as evidence has shown that the disappearance of malaria in parts of Europe was as a result of the economic development of Europe and not due to vector control measures [17].

2. MATERIALS AND METHODS

2.1 Population and Sampling

With 37 States and a landmass of about 925,000 square kilometers, Nigeria, a tropical climatic country has distinct internal sub-climatic and vegetation belts. This internal variation reflects in

the spatial prevalence rates of malaria in the country with the most affected region, with 90% prevalence rate, being around the Rivers Niger and Benue in North-Central Nigeria. Malaria mortality rate among the children under the age of 5, put at 50.3%, is, however, highest in the South-West region according to the Nigerian National Malaria Elimination Programme (NMEP) [18]. The region also has a prevalence rate that is between 40% and 70% [19]. Ibadan, the erstwhile regional capital of the South-West region and the headquarters of Oyo State was purposively selected for the study due to the high malaria mortality rate in the region and for the availability of reliable records on clinically-diagnosed cases of malaria for the 30-year period of investigation. Such historical records are either unavailable or incomplete in other locations. Ibadan also presents a good breeding local climate for the proliferation of mosquitoes with its 8 - 9 months of annual precipitation and a mean annual temperature of 27℃.

2.2 Data Types and Sources

Secondary data were employed for the study. The climatic data employed are the mean maximum temperature (MMT) and the mean annual rainfall (MAR) of Ibadan. The socioeconomic indices used are national inflation rate (INF), national unemployment rate (UNM), national poverty level (PVT), as well as capital expenditure on health as a quotient of the national budget (HCE). The socioeconomic variables are national average values which describe how well the national economy is and are reflective of the levels of social wellbeing of the population and individual households across locations within the country. The choice of health expenditure is particularly to assess the level of government spending on social services in the country, especially on health infrastructure. Reduced government spending on social services is an economic policy in Nigeria since 1986 when the Structural Adjustment Programme (SAP) was introduced as an economic policy [20]. Data on clinically-diagnosed cases of malaria was also employed. All the data sets were obtained for the 30-year period (1985 to 2014) to allow for an extensive temporal analysis and to date back a year before the outset of the prevailing national economic policy which is expected to have fully impacted on the national economic development and individual quality of lives.

The climatic data were sourced from the Ibadan Station of the Nigerian Meteorological Agency (NIMET) while the socioeconomic data were sourced from various government publications including Annual Reports of the Central Bank of Nigeria (CBN), CBN Economic Review and Quarterly Publications, Abstract of Statistics of the National Bureau of Statistics, annual budget estimates of the Federal Government, as well as from IMF and World Bank data where such was not found in any government publication. Data on the prevalence of malaria was sourced from the University College Hospital (UCH), the State Hospital at Ring Road (SHRR) and Adeoyo Maternity Teaching Hospital (AMTH) in Ibadan. The health facilities predate 1985, the starting point for climatic data collection, and are owned by the government with a capacity for record keeping and reliability. As the datasets are in the public domain and their collection did not involve interactions with human subjects, ethical approvals were not required for the study.

2.3 Data Analysis

The 1985 - 2014 data on clinically-diagnosed cases of malaria were analyzed preliminarily for consistency and reliability using statistical measures of Standard Deviation and Kurtosis. The Pearson Product Moment Correlation technique was thereafter used to analyze the trend in the data set as well as in the climatic and socioeconomic data. The data sets were thereafter employed as input data for a multiple linear regression analysis where malaria prevalence data was the dependent variable and the climatic and socioeconomic indices were the independent variables. The maximum likelihood method was employed to appreciate the goodness of fit of the regression model. The multiple regression analysis has the capacity for predicting a dependent variable from several independent variables where both sets of variables have a linear relationship. The resulting regression equation was thereafter used for a linear projection of future incidence of malaria from the year 2014 to 2050 using the re-computed predicted values of malaria prevalence between 1985 and 2014.

3. RESULTS AND DISCUSSION

3.1 Trend of Variables

Neither the AMTH nor the SHRR was able to provide malaria records before 2001 due to improper handing-over of records, non-

computerization of record keeping, industrial actions, and renovation of facilities among others. The available data was therefore insufficient for a longer temporal analysis and was discarded when it returned very high Standard Deviation and negative Kurtosis values based on the marked variation in the year-on-year comparison in sharp contrast to the national trend in malaria prevalence. The UCH data, on the other hand, covered the 30-year period and was also consistent in distribution and dispersion. The highest number of malaria cases recorded between 1985 and 2014 was 3,671 in the year 2000 followed by 3,067 in the year 2006 while the lowest was 1,036 in 1993 (Fig. 1). The trend analysis indicates that over the years, the incidence of malaria has not reduced but witnessing a gradual and almost negligible increment (r = .17).

The highest volumes of mean annual precipitation recorded in the study area were 151.24 mm in 1999, 148.95 mm in 2011 and 133.55 mm in 1985 while 1998, 1992 and 1997 were the driest years with a mean annual precipitation of 84.83mm, 90.72 mm and 91.43 mm respectively. Mean maximum temperature in the study area ranged between tween 31.15℃ and 33.27℃. While the lowest temperature was recorded in 1985, the highest was in 1998. The apparent fluctuations in rainfall notwithstanding, the trend analysis shows that precipitation in the study area has increased minimally (r = .06) over the years. Ditto for temperature (r = .03). Fig. 2 illustrates the temperature and rainfall pattern in the study area.

From 5.5% in 1985, the national inflation rate went to as high as 57.2% in 1993 and declined to 8.00% at the end of 2014. The unemployment rate was in a single digit between 1985 and 1998 and oscillated between 19.9% and 27.4% in the period 1999 to 2013. It dipped to 6.4% at the end of 2014. The national poverty level was at its highest points of 72% and 71.5% in 1999 and 2014 respectively and stood at 33.1% in 2013. The national poverty level represents the percentage of Nigeria's total population living on the equivalent of less than $1.00 a day. Capital expenditure on health-care in Nigeria has largely been less than 1% of the country's annual budget each successive year since 1985 except for a few instances. It was a paltry 0.18% of total budget in 1993 and 0.20% in 1992. The trend from 1985 to 2014 has oscillated between 0.43% and 1.91%. Of all the socioeconomic variables, unemployment rate recorded the highest increase (r = .70) over the successive years. Fig. 3 illustrates the distribution.

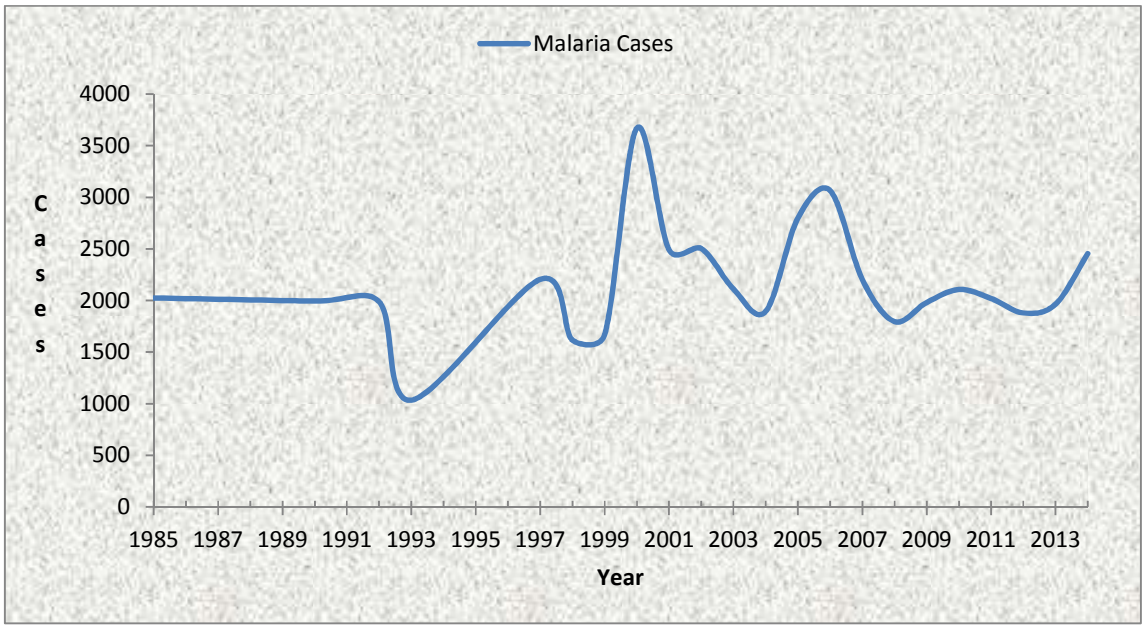

Fig. 1. Trend of malaria prevalence in Ibadan 1985 – 2014

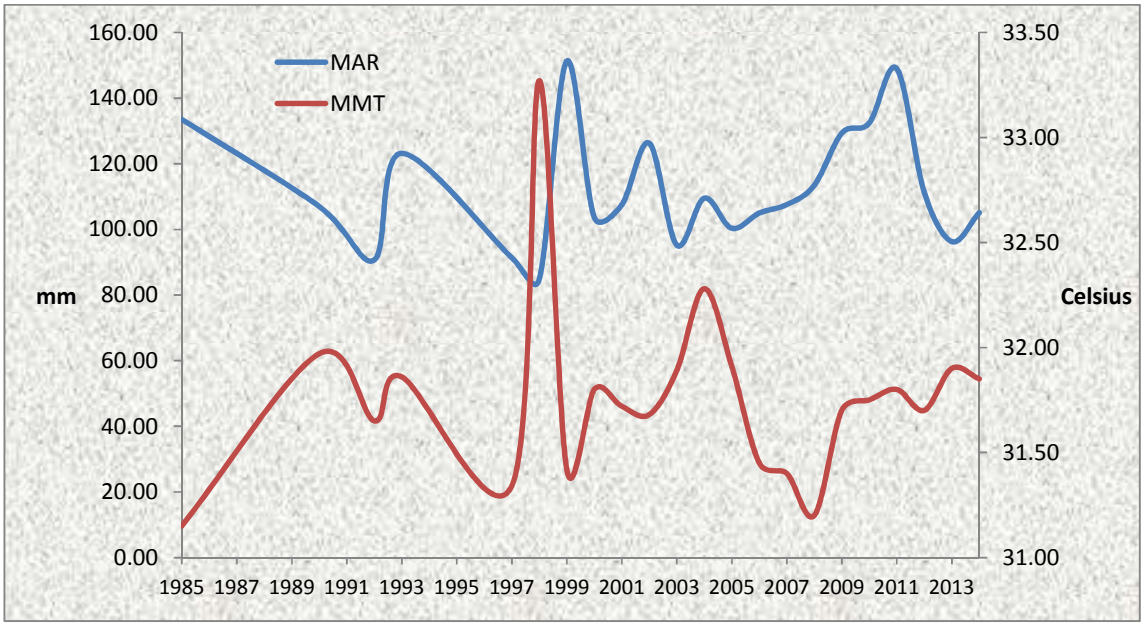

Fig. 2. Trend of climatic parameters in Ibadan 1985 – 2014

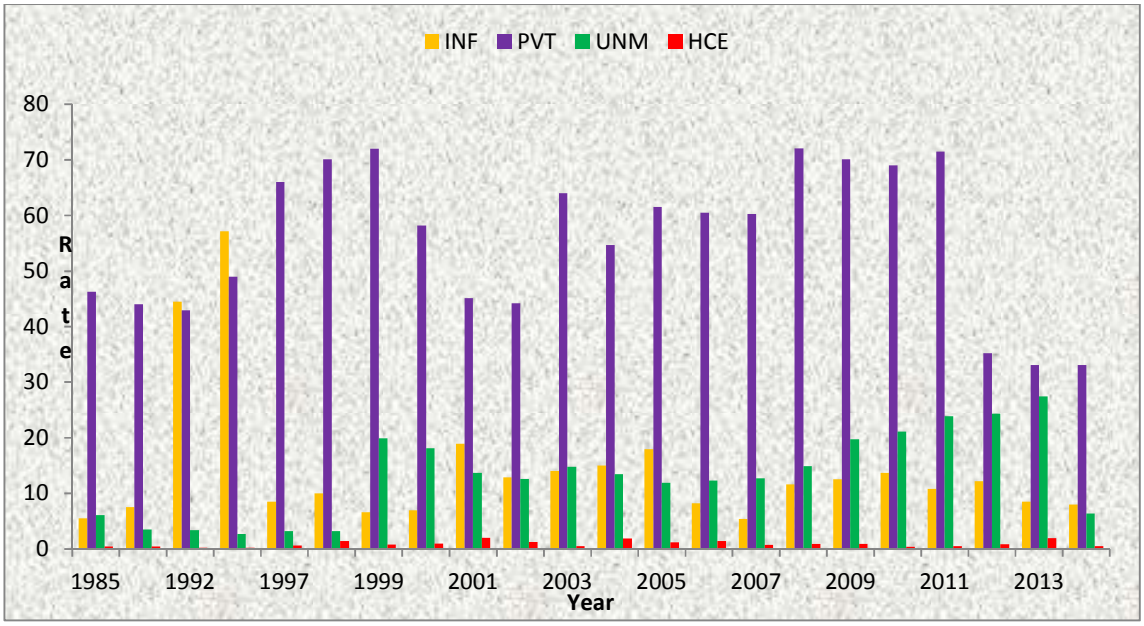

Fig. 3. Trend of socioeconomic indices in Nigeria 1985 – 2014

3.2 Malaria Prevalence and the Predictors

The result of the regression analysis between climatic parameters and socioeconomic variables, and malaria prevalence shows a Coefficient of Determination (R^2) value of 0.786 and a standard error of the estimated value of 0.044. This implies that the six independent variables collectively accounted for 78.6% of the variation in the incidence of malaria in the study area with a 4% margin of error. This high Coefficient is indicative of the fact that the six independent variables employed in the regression analysis are a good predictor of the dependent variable. The result is also statistically significant ($P < .001$). Of the six independent

variables, inflation rate (INF) with a beta coefficient of -0.620 contributed the highest to explaining the variance in malaria prevalence in the study area, closely followed by mean annual rainfall (-0.516) and mean maximum temperature (-0.436). Capital expenditure on health had a coefficient of 0.151 while unemployment rate and poverty level had coefficients of 0.115 and -0.030 respectively. Based on the results of the correlations and collinearity statistics coefficients as well as the variance inflation factor (VIF) values, the variables employed were appropriate for the regression analysis with respect to the multicollinearity assumptions in regression. The regression equation is thus written as;

$$y = 6.184 + [(-0.620)(INF)] + [(-0.516)(MAR)] + [(-0.436)(MMT)] + [(0.151)(HCE) + [(0.115)(UNM)] + [-(0.030)(PVT)].$$

3.3 Projection of Future Distribution of Malaria Incidence

The projection of future distribution of malaria incidence in Ibadan was done using the predicted values of the malaria prevalence data. The predicted values were computed from the original prevalence data while running the regression analysis. The values are derived by employing the regression equation to re-compute the initial values of malaria incidence by including the error term and factoring-in the contributions of each of the six independent variables. Using the predicted values rather than the absolute values for the projection of future distribution of malaria prevalence is, therefore, more appropriate as the influence of the six predictors that accounted for nearly 79% of the variations in malaria prevalence have been taken into account. The method of projection employed is the linear projection method using the trend pattern of malaria incidence between 1985 and 2014.

As the malaria prevalence data employed was from a single health facility but indicative of the general trend in the study area, the data was converted to rates to enable a generalization and allow for situational comparison in the future. The study employed hospital catchment figure as the denominator in converting the prevalence data to prevalence rates. With the projected population of Ibadan being 1,722,318 as at 2014 and the number of hospitals being 234 according to the records of the Oyo State Ministry of Health, the computed hospital catchment population for hospitals in Ibadan is 7,360. Following from this, the prevalence rate of malaria in Ibadan in 2014 was 299 cases per 1,000 Population (or 29.9%). By the year 2050, the projected rate is computed to be 366 cases per 1,000 Population (or 36.67%) if the contributory factors were not controlled. The projected rates are alarming and suggest that more needs to be done by the government in eradicating malaria in Nigeria. The current attention on treatment control and drug administration by the Nigerian ministry of health is a post-mortem and will therefore not be adequate for a total eradication of the malaria scourge in Nigeria. People only seek treatment and take drugs when they are ill, this does not prevent transmission. The projected trend is illustrated in Fig. 4 while Table 1 shows the projected incidence and incidence rates from 2016 to 2050.

The contribution of each of the independent variables shows that there is an inverse relationship between all the independent variables and the dependent variable save for health expenditure and unemployment. In other words, the relationship shows that one unit of increase in inflation and poverty rates (which implies a decrease in living standards) will lead to an increase in malaria prevalence in the study area by 0.620 and 0.030 units respectively. It also implies that with more rainfall and increased temperature, malaria prevalence increases by 0.516 and 0.436 units respectively. The magnitude and direction of relationships between the independent variables and malaria prevalence are equally evident in the values of partial correlations between the variables.

From the results, inflation, rainfall, and temperature are strongly and negatively correlated with malaria prevalence. The respective correlation coefficients were -0.764, -0.656 and -0.633. The correlation coefficients are equally significant at $P = .01$. This again shows that as the population's standards of living decline and the study area record higher precipitation and increased temperature, the incidence of malaria increases. For health expenditure, unemployment and poverty, the respective correlation coefficients were 0.250, 0.192 and -0.059. In all the three cases, none of the results is significant at $P = .01$. This implies that although there is a relationship between these set of variables and malaria prevalence, the relationship is not strong to significantly influence malaria prevalence.

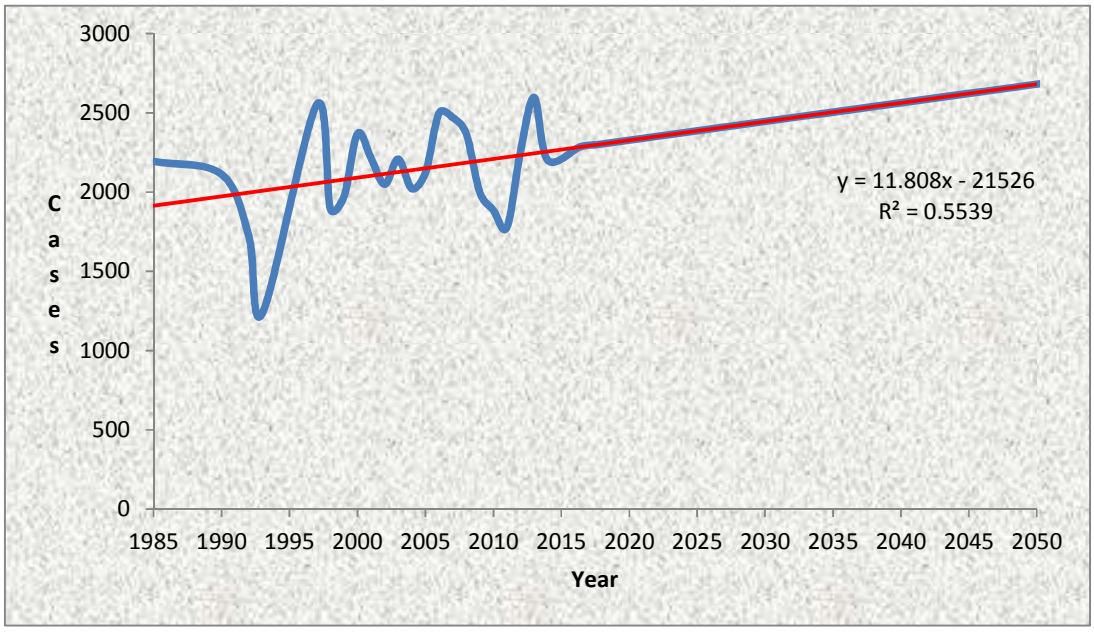

Fig. 4. Trend and projected incidence of malaria in Ibadan (Predicted Values)

Table 1. Projected incidence and incidence rate of malaria in Ibadan 2016 – 2050

S/N	Year	Projected malaria incidence	Projected malaria incidence rate (per 1,000 Population)
1	2016	2,284	310
2	2020	2,326	316
3	2024	2,368	322
4	2028	2,424	329
5	2032	2,467	335
6	2037	2,523	343
7	2040	2,565	349
8	2044	2,607	354
9	2048	2,649	360
10	2050	2,691	366

Source: Authors' Computation, 2017

From these findings, the influence of a change in temperature and rainfall on the prevalence of malaria is as found in other studies in Nigeria [9,21] and elsewhere [10,11,22-24]. Further, the contributions of the socioeconomic variables also show that malaria prevalence is affected by the populations' levels of social wellbeing and quality of lives as found in other studies [12,25-26]. This study has however shown that beyond climate change (environmental factors), socioeconomic factors play very important roles in explaining disease prevalence as implied in the United Nations' paradigm shift to focusing on social and economic determinants in the understanding of causes of illness and diseases. With a beta coefficient of -0.620, the impact of inflation as a socioeconomic factor affecting malaria prevalence is most profound from this study. The impact of inflation as a socio-economic factor can be better understood with respects to the population's per capita income and consumer price index (CPI).

The per capita income in Nigeria was $950 in 1985 and has witnessed a sharp decline over the years to less than $350 in 2012. Between 1986 and 2012, the lowest per capita income in Nigeria was $204 in 1995 while the highest was $390 in 2004 [27]. Meanwhile the per capita income in Canada is about $52,000 and almost $2,000 in Ghana. In 1985, the CPI was 8.5%, it was 60% 10 years later in 1994 and 176% in the

year 2000. More recently and using 2009 as the base year, the CPI has increased from 100% to 164.4% at the end of the year 2014 [28]. These show that between 1985 and 2014, the disposable income of the average citizen in Nigeria has shrunk greatly while prices of goods and services have increased astronomically. This combination has implications for the population's feeding pattern and nutritional quality, their housing conditions and quality of living environment, and other conditions that impact the population's susceptibility and exposure to diseases. It also has implications for the population's treatment-seeking behavior regarding type, quality, and cost. In the face of dwindling disposable income and rising inflation, therefore, the population is at a greater disadvantage in protecting themselves from and treating malaria when ill.

4. CONCLUSION

From the foregoing, it has been shown that both climatic and socioeconomic conditions greatly influence the prevalence of malaria in Nigeria. The impacts of the socioeconomic factors, particularly inflation, as predictors of the prevalence pattern of malaria in the study area suggests that the national economy requires quick fixes if the nation is to achieve meaningful progress in her malaria eradication drive. Poor socioeconomic conditions affect household incomes, take their toll on nutrition, and lower the population's immunology and ability to fight disease pathogens. The conditions also affect the population's capacity to seek quality treatment thereby perpetuating diseases prevalence. While climate change may not be entirely controllable, resilience building and adaptation techniques to cope with the changes are also influenced by socioeconomic conditions, especially on housing and residential habitat quality. This manifests as inadequate housing infrastructure, poor ventilation, over-crowding, water and sanitation problems, and poor drainage system among others. Addressing these underlying conditions is more important for diseases eradication than tackling the obvious proximal causes of diseases.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable as the data employed are in the public domain.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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