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MALARIA AND AGRICULTURAL PRODUCTION IN NIGERIA

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ABSTRACT

Malaria has adverse effect on agricultural production in Nigeria. This study examined the effect of malaria morbidity on the agricultural Gross Domestic Product (GDP) in Nigeria as well as predicts the future incidence of malaria in Nigeria. Secondary data employed in the study were analyzed using descriptive statistics, production function and Markov chain analysis. Findings from the study revealed that the highest percentage change in malaria morbidity and mortality were recorded in the period between 1996 and 2000 just before the Millennium Development Goal declaration. Malaria impacted negatively on agriculture production in the country both in the short and long-run. For every one reported case of malaria per 100,000 persons in the country, while holding other explanatory variables constant, Agric. GDP will reduce by N 0.762 per year. Projections of malaria morbidity in Nigeria revealed that by the end of the year 2040, the number of people that will die of malaria for every reported case will increase. The paper recommends that efforts should be directed towards the complete extermination of malaria vectors.

Contribution/ Originality: This study contributes to the existing literature on the effect of malaria disease on agricultural gross domestic product in Nigeria so as to help in developing more effective approaches towards reducing its negative affect on agriculture as well as its eradication in the country.

1. INTRODUCTION

Nigeria is a West African nation. It is situated in the Gulf of Guinea, stretching between Latitudes 4^0 and 14^0 North. The country has a land mass of about 924 000 km^2. It is the fourteenth largest country in Africa and also the most populous nation in Africa; the eighth most populous country in the world, with an estimated total population of 158 million (World Population Prospects, 2008).

A large percentage of the agrarian population (rural population) in Nigeria has been plagued with several disease conditions which have deleterious consequence on their health and productivity. One of such intractable diseases of the agrarian population is malaria. Nigeria is among malaria endemic countries located in the Sub-Saharan Africa and contributes more than a third of the total African malaria burden. The world Health Organization Rankings for malaria mortality places Nigeria at the 11th position in 2011 out of 192 countries (World Health Organization (WHO), 2011). It has become more than a health issue in the country and it is the most prevalent of all major tropical diseases in the country.

Agriculture is estimated to be a larger contributor to employment and non-oil foreign exchange earnings in Nigeria, implying that it holds much potential for enhancing and sustaining economic growth. However, in the face of malaria illness affecting agricultural labour especially in agrarian communities where most agricultural activities take place, there is need to estimate the effect of malaria on agricultural GDP as well as examine the present and future situation of malaria in the country. This will be helpful to Nigerian government and development partners in formulating policies that will curb the effect of malaria in rural areas in Nigeria especially at this onset of Sustainable Development Goals (SDGs). The economic burden of malaria on agricultural GDP is the total reduction (or loss) in Agricultural GDP (output) that is associated with malaria illness. This study therefore attempts to answer the following research questions:

(i) What is the malaria situation in Nigeria?

(ii) How does the burden of malaria affect agricultural production in Nigeria?

(iii) Given the current trend, how will the future situation of malaria affect agricultural production in Nigeria?

The main objective of the study was to examine the effect of malaria morbidity on agricultural production in Nigeria and to predict the future malarial situation. The specific objectives were to:

i. provide stylized fact on malaria morbidity and mortality in Nigeria ;

ii. investigate the effect of malaria morbidity on Agricultural Gross Domestic Product in Nigeria;

iii. project the future burden of malaria and its implications to the Nigerian economy.

2. MATERIALS AND METHODS

2.1. Nature and Sources of Data

This paper focused on impact of malaria morbidity on agricultural production in Nigeria viv-a-vis agricultural. It employed secondary data obtained from Annual Report and Statements of Account of the Central Bank of Nigeria, (various issues) and publications of National Bureau of Statistics. The data cover the period between 1976 and 2010.

2.2. Methods of Data Analysis

The data collected were analyzed using descriptive statistics namely percentages as well as graphs. This was used to achieve the first objective. Besides descriptive statistics, regression and Markov chain analyses were employed to gauge the relationships between malaria morbidity and Agricultural Gross Domestic Product as well as to predict the future situation of malaria in Nigeria. The regression model is presented below:

The implicit form of regression equation used is stated as:

$$\ln RAGDP = \; f\,(\ln LA, \ln CAS, \ln MI, \; \ln INF\,, \ln CRD, U_{it}) \qquad (1)$$

The explicit model is:

$$\beta_0 + \boldsymbol{\beta_1} \ln LA + \boldsymbol{\beta_2} \ln CAS + \boldsymbol{\beta_3} \ln MI + \boldsymbol{\beta_4} \ln INF + \boldsymbol{\beta_5} \ln CRD \; + U_{it}) \qquad (2)$$

Where $\ln RAGDP$= Real Agric GDP (in Million Naira); $\ln LA$ = labour employed in Agriculture (in Million); $\ln CAS$= Capital stock employed in Agriculture (in Million Naira); $\ln MI$= Malaria Index; $\ln INF$= Inflation or general price changes captured by consumer price index; $\ln CRD$= credit available for agriculture (in Million Naira); U_{it}) = stochastic error term; ln = natural log; β_0=intercept; β_0-β_5= coefficients of explanatory variables.

A priori, it is expected that as malaria attacks become more prevalent (i.e. as M increases), Y falls. Put more

precisely, f_{LA}, $f_{CAS}, f_{CRD} > 0$ and $f_{MI}, f_{INF} < 0$ (3)

2.2.1. Data Measurement

Labour: Labour employed is measured by the total number of people employed in agriculture in Nigeria. It positively impacts on agricultural output. However, malaria can affect labour through reduced work performance and labour loss in cases of death of the affected person.

Capital stock: Capital is an input into the economy's production function. Increased capital stock employed in agriculture leads to increased economic growth. However, increased malaria incidence affects capital indirectly through the effects on savings which negatively affects investments and ultimately capital needed for agriculture.

Malaria Index: this was measured by the number of reported cases of malaria per 100,000 persons. It is expected to be a good proxy for the intensity of malaria attacks – including cases not reported. It was computed following McCarthy *et al.* (2000) methodology. This is given as:

$$M = \frac{Total\ malaria\ cases\ reported\ in\ the\ zone}{Total\ population\ of\ people\ in\ the\ zone} \text{x}100{,}000 \qquad (4)$$

Inflation: this was included in the regression to capture economic stability. The variable is captured by consumer price index obtained from various issues of the CBN Annual Report.

Credit: credit is needed for agricultural expansion. It can be used to stimulate agricultural output.

2.2.2. Markov Chain

Information relating to the observed probabilities of past trends, say over the last thirty years, can be organized into a matrix which is the basic framework of a Markov model. A transition probabilities is square, this is because all possible states must be used both as rows and as columns; all entries are between 0 and 1, since all entries represent probabilities; the sum of the entries in any row equals 1, (the numbers in the row gives the probability of changing from the state at the left to one of the states indicated across the top). An absorbing Markov chain was used, since health dynamics is an absorbing Markov chain (Aruofor, 2003; Aruofor, 2009). A state in a Markov chain is an absorbing state if it is impossible to leave it; i.e., pij= 1 when $\boldsymbol{i = 1}$. An absorbing state is a state that once entered do not leave. It is a state of having zero probability of being left once entered.

The transition matrix for any absorbing chain can be written in the "canonical" form

$$P = \begin{bmatrix} I & 0 \\ R & Q \end{bmatrix}$$

Where R is the rectangular sub-matrix giving transition probabilities from non-absorbing to absorbing states, Q is the square sub-matrix giving these probabilities from non-absorbing to non-absorbing states, I is an identity matrix, and 0 is a rectangular matrix of zeros. The probabilities $P(X_o = i) = II_o$define a vector $II_o = (II_o(1), II_o(2), \ldots, II_o(k), \ldots)$

which satisfy (a) $Ho\ (i) \geq 0$ (b) $\sum i\epsilon_{Ik} II_o(i) = 1$. The vector II_o is the initial distribution of the Markov chain while the probabilities $II_{Ii}(i) = P(X_{Ii} = i)$, define a vector $II_{Ii} = (II_{Ii}(1), II_{Ii}(2), \ldots II_{Ii}(k))$ which is the distribution at time n.

It is known that: $II_n = II_o P^n$ (5)

whereP^n is the *nth* power of the transition matrix P.

Equation (5) can be interpreted as: If the components of II_o represent the number of malaria cases at the present time (year) in Nigeria, then II_2 can be predicted after two units of time (years), say, to be $II_o P^2$. That is, the expected number of malaria cases in Nigeria after a number of years is uniquely determined by II_o and P (*i.e.* by multiplying initial probability vector by transition probability).

The number of reported malaria cases in Nigeria was used for this analysis. Information relating to malaria morbidity and mortality in Nigeria for the past thirty years was used to construct the transition matrix (i.e. between 1981 and 2010).From the data, for every 100 reported cases of malaria, 99.82% resulted only in morbidity while 0.18% resulted in mortality. The assumption is that a person who contracts malaria once in year t is prone to contract the same in year $t+1$ and that population in the country remains the same. The data used for this analysis were obtained from National Bureau of Statistics (2011). As at the time of this study, only 2010 set of data were available, hence, 2010 were used as the base year for the analysis.

3. RESULTS

3.1. Results

3.1.1. Malaria Situation in Nigeria

Table 1 and Figure 1 present results of the percentage change in Malaria morbidity and mortality in Nigeria. From the results, there were variations in malaria morbidity and mortality in Nigeria throughout the period covered by the study. Malaria morbidity was at its ebb in the period 1986-1990 but this was followed by a sharp rise the following period. The period between 1996 and 2000 recorded the highest figure (peak) which was followed by a short fall between 2001 and 2005; however, malaria morbidity experienced a rise towards the last period covered by the study. This suggests that more measures need to be put in place to stem out malaria morbidity in Nigeria. In like manner, malaria mortality recorded the highest figure in the period between 1996 and 2000. This was followed by a drastic fall the following period. However, the last period covered by the study (between 2006 and 2010) experienced another rise in mortality. If the pattern of decline experienced in the period between 2001 and 2005 had been maintained, malaria mortality could have been brought under control in Nigeria.

Table-1. Malaria morbidity and mortality in Nigeria

Year	Malaria Morbidity (Average value)	Percentage change	Malaria mortality (Average value)	Percentage change
1976-1980	1,177,840	-	-	-
1981-1985	1,283,909	9.01	1,038	-
1986-1990	1,055,898	-17.76	1,675	-61.37
1991-1995	1,077,635	2.06	1,857	10.87
1996-2000	1,813,736	68.31	5,104	174.85
2001-2005	2,735,942	50.85	4,885	-4.29
2006-2010	4,160,070	52.05	8,853	81.23

Source: Computed by Authors from NBS- Annual Abstract of Statistics (Various Editions)

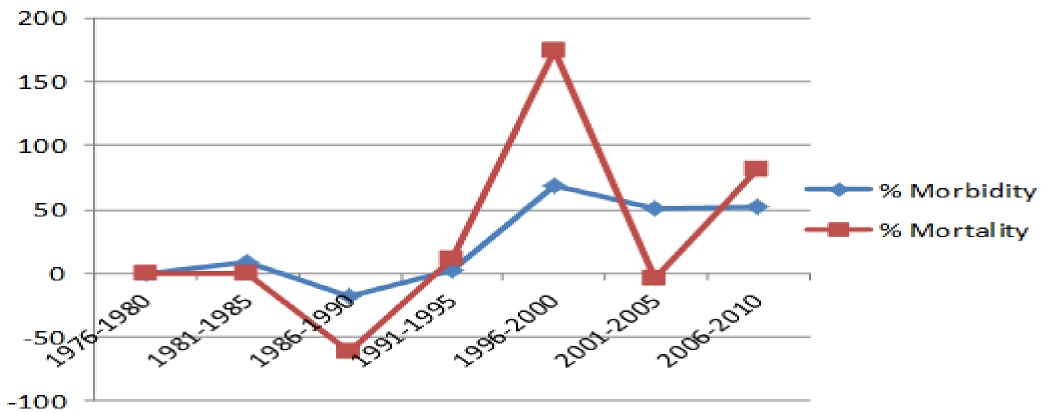

Figure-1. Percentage change in Malaria Morbidity and Mortality in Nigeria

Source: Computed by Authors from NBS- Annual Abstract of Statistics (Various Editions)

3.1.2. Effect of Malaria Morbidity on Agricultural Gross Domestic Product

The result of the stationarity test for the effect of malaria morbidity on agricultural GDP is presented in Table 2. Result in Table 2 indicates that five variables were not stationary at levels: four of these variables Labour (LA), Malaria Index (MI), and Credit (CRD) each became stationary after first differencing at1% levels and that of Inflation (INF) at 5% level. This indicates that a possible stable relationship can only be obtained at first difference. One variable – Capital Stock employed in agriculture (CAS) became stationary after second differencing at 5% level of significance, indicating that a possible stable relationship can only be obtained at second difference. However, one variable was stationary at levels: Agric. GDP (RAGD) at 1% level of significance.

Table-2. Summary of stationarity test for effect of malaria morbidity on agricultural GDP

Variables	At level	1st Difference	2nd Difference	Order of Integration
Agric. GDP(RAGDP)	3.906***	_	_	I(0)
Labour (LA)	0.104	-5.377***	_	I(1)
Capital Stock (CAS)	-2.254	-0.607	-3505**	I(2)
Malaria Index (MI)	-2.071	-8.054***	_	I(1)
Inflation (INF)	-1.655	-5.474**	_	I(1)
Credit (CRD)	-1.506	-10.621***	_	I(1)

Note: *** = Significant at 1%; ** =Significant at 5%

Source: Computed by Authors

Co-integration test was carried out as a condition for accepting the Error Correction Mechanism (ECM) model (See Table 3). This test is necessary so as to establish whether there is a long- run relationship between the dependent variables and their fundamentals. This was done by running the residuals from the static regression. The result of the trace test and max-eigen value test indicate that there is at least one co-integrating equation at 5% level. The result reveals that this variable (Agric. Real GDP) is co-integrated. This means that there is a long-run relationship between it and its respective determining variables, hence, there is the existence of an equilibrium position amongst these variables and they share common trends.

Table-3. Result of Johansen unrestricted co-integration test for malaria morbidity and agricultural GDP in Nigeria

Hypothesized No of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.659008	99.09752	95.75366	0.0288
At most 1	0.561314	62.51706	69.81889	0.1664
At most 2	0.327954	34.50207	47.85613	0.4746
At most 3	0.243480	20.98950	29.79707	0.3583
At most 4	0.209671	11.50261	15.49471	0.1824
At most 5	0.097879	3.502209	3.841466	0.0613

* denotes rejection of the hypothesis at the 5% level; Trace test indicates 1 co-integrating equation at 5%;

Result of analysis (2014); Trend assumption: Linear deterministic trend;

Series: LnAGDP, LnLA, LnCAS, LnMI, LnINF, Ln CRD; Lags interval (in first differences): 1 to 1; Unrestricted co-integration rank test (Trace)

Source: Computed by Authors

Since the variables are non-stationary at their levels, but stationary after first differencing and also shows co-integration, the next stage is to formulate an error correction model. This is necessary so as to recover the long-run information lost by differencing the variables. The result of parsimonious ECM (see Table 4) shows that variability in Agricultural GDP in Nigeria is significantly explained by its previous year value and its value lagged by two years RAGDP (-1), ARGDP (-2), Capital accumulation in Agriculture (CAS) both at present, in the previous year and lagged by two years. Apart from these variables, Malaria Index (MI (-1)) in the previous year, and availability of Credit both in the previous year and lagged by two years (CRD (-1); CRD (-2)) are also part of the significant explanatory variables that explained the variability in Agric GDP (RAGDP). The coefficients of CAS (-1), and RAGDP (-1) are correct signed at 1%. The coefficients of MI (-1), CRD (-1) and CRD (-2) are correct signed at 5%. This implies that an increase (decrease) in each of these variables significantly increases (decreases) the present value of Agric. GDP.

An increase in Capital Accumulation for Agriculture both at present and lagged by two years [CAS, CAS (-2)] will reduce Agricultural GDP by ₦ 1.193 and ₦ 1.799 respectively. This implies underutilization of capital both at present and in the past but Capital accumulation in the previous year [CAS (-1)] will increase Agricultural GDP by ₦ 1.800. The coefficient of Malaria Index being -0.762 implies that for every one reported case of malaria per 100,000 persons in the country, while holding other explanatory variables constant, Agric. GDP will reduce by ₦ 0.762 per year. Availability of Credit impacts positively on Agricultural GDP implying that a million naira increase in Credit (both in the previous year and lagged by two years) will increase agricultural GDP by ₦ 0.551 and ₦ 0.309 respectively. This suggests that as more loans are made available for agriculture, the more the growth in Agricultural GDP. The lagged error correction term ECM (-1) is negative and statistically significant at 5%; which confirms that long run equilibrium relationship (co-integration) exists amongst the variables. The adjusted R-squared of the estimated model shows that about 87.1 per cent of the variation in Agric. GDP was explained by the combined effects of the explanatory variables, while the F-statistic shows that the overall regression was significant at 1 per cent level.

Table-4. The parsimonious error correction model for the effect of malaria morbidity on agricultural GDP

Variable	Coefficient	Standard Error	t- Statistics
D(LnCAS)	-1.193***	0.320	-3.724
D(LnCAS(-1))	1.800***	0.239	7.528
D(LnCAS(-2))	-1.799***	0.461	-3.902
D(LnMI(-1))	-0.762**	0.330	-2.305
D(LnCRD(-1))	0.551**	0.216	2.549
D(LnCRD(-2))	0.309**	0.127	2.443
D(LnRAGDP(-1))	0.59***	0.180	3.294
D(LnRAGDP(-2))	-0.22*	0.11	-1.98
ECM(-1)	-0.613**	0.248	-2.466
R-squared	0.871	Mean dependent variable	0.119
Adjusted R-squared	0.743	S.D. dependent variable	0.377
Durbin-Watson stat.	2.198	S.E. of regression	0.191
F-statistic	6.779***	Sum squared residual	0.584

Note: ***=Significant at 1% level; **= Significant at 5% level; *= Significant at 10% level

Source: Computed by Authors

3.1.3. Prediction of Future Malaria Morbidity in Nigeria

The transition matrix for malaria morbidity and mortality in Nigeria is presented in Table 5. The Table indicates the probability of going from one state in period *t* to another state in period *t+1*. For example, the probability of a malaria patient in year t dying of malaria in year t+1 is 0.0018, while of remaining a malaria patient in year t+1 is 0.9982. In malaria morbidity and mortality transition matrix, there is one absorbing state, which when entered, cannot be exited. This is death by malaria. Hence, the probability of a patient who died of malaria in year t, being sick of malaria in year t+1 is 0, while of remaining dead in year t+1 is 1.

Table-5. Transition matrix for malaria morbidity and mortality in Nigeria

	t+1	
t	**Malaria Morbidity**	**Malaria Mortality**
Malaria Morbidity	0.9982	0.0018
Malaria Mortality	0	1

Source: Computed by Authors

Given the revealed transition matrix which represents the stochastic force driving the system, all that was needed to predict the future state was to stimulate it from 2010 to 2040. The prediction was facilitated by the use of Microsoft Student with Encarta Premium Mathematics 2008 (a matrix calculator). Since in Markov chain the stochastic forces driving the system do not change, no sensitivity analysis is required. The likely future states are as predicted given a baseline population (Aruofor, 2009). Table 6 presents the empirical details of the future predictions of malaria morbidity and mortality in Nigeria. It is assumed that all things being equal (ceteris paribus), the population of people in Nigeria remains the same every year.

The model predicts that malaria morbidity will fall steadily from 2010 to 2040. On the other hand, by year 2022, malaria mortality will reach an asymptote of about 1 million cases per year and increase to 2 million (cases per year) by the year 2035 and beyond. If for every one reported case of malaria per 100,000 persons in the country,Agric. GDP reduces by ₦ 0.762 per year, how much more death due to malaria? Hence, there is an urgent need to take more proactive steps towards eliminating malaria in Nigeria.

Table-6. Future malaria morbidity and mortality in Nigeria (10million)

Year	Malaria Morbidity	Malaria Mortality
2010	0.4569804	0.0004308
2011	0.4561574	0.0012526
2012	0.4553364	0.0020736
2013	0.4545167	0.0028933
2014	0.4536986	0.0037114
2015	0.4528820	0.0045280
2016	0.4520668	0.0053432
2017	0.4512531	0.0061569
2018	0.4504408	0.0069692
2019	0.4496300	0.0077800
2020	0.4488207	0.0085893
2021	0.4480128	0.0093972
2022	0.4472064	0.0102036
2023	0.4464014	0.0110086
2024	0.4455979	0.0118121
2025	0.4447958	0.0126142
2026	0.4439952	0.0134148
2027	0.4431960	0.0142140
2028	0.4423982	0.0150118
2029	0.4416019	0.0158081
*2030	0.4408070	0.0166030
2031	0.4400136	0.0173964
2032	0.4392215	0.0181885
2033	0.4384309	0.0189791
2034	0.4376418	0.0197682
2035	0.4368540	0.0205560
2036	0.4360677	0.0213423
2037	0.4352828	0.0221272
2038	0.4344992	0.0229108
2039	0.4337171	0.0236929
2040	0.4329365	0.0244735

4. DISCUSSION

4.1. Malaria Situation in Nigeria

The burden of malaria is a challenge to human development. In Nigeria, malaria is the prime among the top three causes of death in the country (National Malaria Control Programme (NMCP), 2005). It is also the leading cause of mortality in children under five years and pregnant women, especially, the first three months of pregnancy. It is a significant cause of adult morbidity. The results of the fact on malaria morbidity in the country show that Nigeria experienced fluctuations in percentage change in malaria morbidity and mortality from one period to another as covered by this study. The highest percentage change in malaria morbidity and mortality were recorded in the period between 1996 and 2000. This period in which very high percentage change in malaria morbidity and mortality was obtained was before the Millennium Development Goal Declaration (which was in year 2000). This implies that activities of Roll Back Malaria Initiative which started in 1998 and other malaria control programmes might have helped to stem out malaria in Nigeria. However, the fact that malaria morbidity and mortality increased towards the last period covered by the study reveals that more measures still need to be put in place to reduce malaria in the future.

4.2. Effect of Malaria Morbidity on Agricultural Gross Domestic Product

Malaria hasnegative impact on economic growth and development. This is because its direct impact is felt by the labour force; but the wealth of a nation is the health of its people. Any negative impact of malaria on availability of labour in a country will definitely affect the growth and wealth of such country. In an agriculturally labor-intensive economy like Nigeria, where agriculture occupies one-third of the GDP and employs two-third of the labour force, the debilitating effect of malaria on Agricultural GDP cannot be overemphasized. This study reveals that malaria morbidity has negative effect on agricultural GDP in Nigeria. For every one reported case of malaria per 100,000 persons in the country while holding other explanatory variables constant, agricultural GDP will reduce by ₦ 0.762 per year. In a populated country like Nigeria, this has severe effect on food production and food security of the populace. The high burden of malaria in the country can lead to decreased long-term economic growth, and works against poverty eradication efforts and socioeconomic development of the country.

The coefficient of capital stock in Table 4 suggests that one million naira increase in agricultural capital stock (in constant prices) leads to about 1.8 million naira increase in agricultural output measured in constant prices on the short run but will reduce agricultural output by 1.2 million naira and 1.8 million naira at the present and in the future . This may be due to depreciation of capital. Hence, efforts need to be made to improve capital accumulation in agriculture both at present and in the future. Availability of credit for agriculture had positive impact on Agricultural GDP. Credit is needed for expansion of agricultural enterprise and for other running expenses in the farm. When this is made available to farmers at the right time, it will encourage more production. As production increases, there will be steady growth in agricultural sector, hence, growth in Agricultural GDP. A million naira increase in credit made available for agriculture would stimulate agricultural output by ₦ 0.551 and ₦ 0.309 at the short run and long run respectively. However, the long run effect is smaller than the short run effect. Hence, loans made available for agriculture need to be properly supervised so that the positive effect of such loan can span productively into the future.

4.3. Prediction of Future Malaria Morbidity in Nigeria

The predictions of malaria morbidity and mortality in Nigeria point to the fact that malaria morbidity will decline steadily. This shows that the various efforts of government and other international partners in stemming out the effect of malaria in the country are yielding good results. However, more effort needs to be put in place to stem out malaria mortality in Nigeria on or before year 2030 (see the year asterisked in Table 6) - the time bound for Sustainable Development Goals. The number of people that will die of malaria for every reported case will increase. This calls for concerted effort towards eradicating malaria in the future. This can only be achieved if measures are put in place to eradicate the malaria vector in the country. If for every one reported case of malaria per 100,000 persons in the country,Agric. GDP reduces by ₦ 0.762 per year, how much more death due to malaria? This calls for more proactive efforts in stemming out the tides of malaria mortality in Nigeria. Since mortality rate is high among children and pregnant women, the implication of this is that future agricultural manpower will be affected when these children die as a result of malaria. Women who perform nearly all the tasks associated with subsistence food production in Nigeria and account for 60 to 80 percent of those producing food crops for household consumption and sale would be lost to malaria in the prime of their age. Hence, measures should be taken to curb malaria mortality in Nigeria.

5. CONCLUSION

Malaria morbidity and mortality experienced inter annual fluctuations. Malaria has negative effect on agricultural GDP in Nigeria (as malaria incidence increases, agricultural GDP falls considerably).This may lead to food shortages, increase importation of food at the expense of food exportation, low Gross Domestic Product, poverty and food insecurity (at both micro level and macro level) as well as retarded economic growth. Considering the predicted figures of malaria morbidity and mortality in Nigeria, it is obvious that there is an urgent need to take proactive steps towards eliminating malaria in the country. Early diagnosis and treatment of malaria need to be carried out to reduce mortality. This is important so as to prevent future production loss emanating from both malaria morbidity and mortality (especially mortality). This study thus recommends that government and development partners should seek measures towards complete extermination of malaria vectors in Nigeria. There should be more funding for researches in the development of vaccine. This will help in total eradication of malaria in Nigeria as save the future generation of hunger and malaria scourge.

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