

Research Article

Incidence of Malaria and Human Capital Development in Anglophone West African Countries

Ameji Enemona Negedu^{1,*} , Charity Philip Sidi² , Abbah Emmanuel Umale¹

¹Department of Economics, Federal University, Lokoja, Nigeria

²Department of Economics, Kaduna State College of Education, Gidan Waya, Nigeria

Abstract

The research investigates the influence of malaria incidence on health outcomes and the advancement of human capital in Anglophone West African nations, covering the timeframe from 2000 to 2023. The stationarity assessment reveals a mixed degree of stationarity, represented as $I(0)$ and $I(1)$ among the variables, with the Human Development Index (HDI) serving as the dependent variable indicative of human capital development, while the Mortality Rate of under-five children (U5M), malaria incidence rate (MLI), adult female mortality rate (ADMF), and adult male mortality rate (ADMM) function as independent variables. Accordingly, the study selects the Pooled Mean Group (PMG) methodology as its estimation approach. The results of the study revealed that in the short-run U5M and MLI all have an inverse relationship with HDI and is insignificant to HDI, while ADMF has positive relationship with HDI, and ADMM have a negative relationship with HDI but both were all having a substantial effect on HDI, while in the long-term all the independent variables have a positive relationship with HDI, only U5M that was found to be significant. Based on the findings, the study recommended that Anglophone west Africa countries should prioritize investments in malaria prevention, diagnosis and treatment, as well as integrate malaria control programs into broader health and education policies.

Keywords

Incidence of Malaria, Human Capital Development, Anglophone West Africa, Pooled Mean Group, Mortality Rates

1. Introduction

Malaria is a disastrous ailment that threatens lives, labour innovativeness and economic development of endemic nations in the world. there were approximately 241 million instances of malaria reported in 2020, with the mortality toll attributed to the disease estimated at 627 thousand [27]. In the African context, malaria, alongside other health afflictions, stands out as a significant impediment to both health and economic advancement for various nations. The World Health Organization (WHO) has indicated that the African Region

bears an inequitable burden of the global malaria incidence, as in 2020, 95 percent of all malaria cases and 96 percent of malaria-related fatalities occurred within Africa [27]. In Sub-Saharan Africa, where the prevalence of the disease is notably acute, malaria results in the death of one in every twenty children under the age of five. Conversely, the mortality rate among adults due to malaria infection is lower than that of infants [26].

Specifically, the WHO revealed that only four African

*Corresponding author: enemona.ameji@fulokoja.edu.ng (Ameji Enemona Negedu)

Received: 19 November 2024; **Accepted:** 9 December 2024; **Published:** 6 March 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

countries which also falls in the Sub-Sahara, accounts for over half of total malaria deaths in the World where Nigeria accounts for 31.9%, Democratic Republic of the Congo with 13.2%, United Republic of Tanzania with 4.1%, and Mozambique with 3.8% [27]. Nigeria, recognized as the most densely populated nation in Sub-Saharan Africa, is projected to have a total population exceeding 216 million by 2022. It is responsible for 27% of global malaria cases and recorded the highest mortality rate of 24% in 2019 [13, 25]. Furthermore, Nigeria contributes to 25% of malaria cases across the African continent, thereby playing a significant role in the annual loss of one million lives in the region, predominantly affecting children and pregnant women, marking the highest rates on the continent. Specifically, deaths attributable to malaria constitute approximately 11% of maternal mortality, 25% of infant mortality, and 30% of mortality in children under five, culminating in roughly 300,000 child fatalities each year [28].

The high cases of malaria incidence in Africa especially in the Sub-Sahara negatively affects household poverty, well-being, prosperity and human development. [30] revealed that due to the rising incidence of malaria, over fifty percent of the nation's populace resides beneath the poverty threshold in Nigeria. Consequently, this portion of the nation's population may find it difficult to afford malaria-related medications, and would result to a surge in mortality rate in Nigeria. As a result, negatively affects the level of human capital accumulation in Nigeria. This notion is supported by most scholars who revealed that improving human capital development will entail reducing poverty rate among households which will in turn, reduce mortality rate where households will be able to afford malaria-related medications, thus, improving innovativeness and well-being, as well as economic progress in Africa [16, 15, 1].

Furthermore, malaria significantly strains the already-stressed health systems in Africa, with nearly 200 million clinical cases reported annually. The disease accounts for up to 60 percent of outpatient consultations and 30 percent of hospital admissions. Additionally, malaria imposes substantial social and economic burdens on families, communities, and the nation as a whole, resulting in considerable financial losses associated with treatment, management, and preventive measures, alongside a reduction in productive work hours [15, 11].

Presently, research indicates that the level of a nation's socio-economic development typically influences governmental investment in healthcare, which subsequently impacts health outcomes and the severity of diseases such as malaria [14, 15]. For example, Nigeria's allocations of 4.1 percent and 3.9 percent of its annual national budget to the healthcare sector in 2017 and 2018, respectively, are markedly insufficient, leading to adverse health outcomes and an escalation in the prevalence and severity of malaria [17]. Consequently, this situation has not fostered improvement in human capital development, reflected in its low gross national income per capita of US\$360.

This tend to give an insight on the general consensus on the deleterious effect of malaria on health status and human development in Africa, most especially in the Sub-African and English-speaking African countries which are still very much under-examined. This lack of attention in the above issue might be an impeding factor in implementing the efficient and effective health policies that would tackle malaria and providing how it links to health outcome and human capital development.

It is upon this premise that the present investigation seeks to analyze the impact of malaria incidence on health status and human capital accumulation in Africa, with a particular focus on the Anglophone West African nations. The Anglophone West African nations, which are also categorized within the Sub-Saharan region, comprise Nigeria, The Gambia, Sierra Leone, Liberia, and Ghana.

2. Review of Related Literature

2.1. Theoretical Framework

This research is grounded in the Health Production Function as articulated by [24]. Fundamentally, the production function represents an equation within the field of economics that delineates the relationship between the quantities of productive inputs (i.e., labor and capital) employed and the resultant output generated. This paradigm posits that the quantity of output achievable from various combinations of inputs is contingent upon the utilization of the most efficient production methods available.

Brems, H. and Hulton, C. R. asserted that aggregate production functions are evaluated to formulate a framework that delineates the extent to which economic growth can be attributed to variations in factor allocation (i.e., the accumulation of physical capital) versus advancements in technology [5, 8]. Specifically, a production function can be articulated in a functional format as represented in Equation (1):

$$Q = f (X_1, X_2, X_3, \dots, x_n) \quad (1)$$

Here, Q signifies the volume of output, while $x_1, x_2, x_3, \dots, x_n$ denote the quantities of input factors (i.e., capital, labor).

According to Wibowo, D. and Tisdell, C, the health production function elucidates the relationship between various health inputs, encompassing both medical and non-medical aspects, and the resultant health output. They contend that it illustrates the interaction of health inputs in producing a specific level of health and elucidates how shifts in health inputs and their combinations can affect health outcomes [24]

Wibowo, D. and Tisdell, C further indicated that in constructing health production functions for a nation, indicators such as morbidity/incidence, mortality rates, infant mortality rates, and life expectancy can serve as metrics for assessing a nation's health status. They propose that M represents mor-

bidity related to either a singular disease (i.e., malaria) or a collective group of diseases. In this context, morbidity is perceived as a function of preventive health programs (P), health care services (C), community environment and housing (H), alongside socio-economic factors (E) [7, 23, 24].

$$M = f(P, C, H, E, \mu) \quad (2)$$

In this equation, M denotes the morbidity of disease (s) (i.e., malaria); P symbolizes preventive health initiatives; C indicates health care services; H refers to the environmental indicators of the nation; E encompasses socio-economic factors, and μ represents the unobserved health stock within the country, commonly referred to as the error term.

Wibowo, D. and Tisdell, C also articulated that preventive health programs (P) may encompass immunization, vector control measures such as insecticide spraying, surveillance for communicable diseases, health promotion and education initiatives, nutritional enhancements, encouragement of breastfeeding, and investments in water supply and sanitation, among others. Health care services (C) may include variables such as healthcare expenditure, availability and utilization of medical services, levels of medical technology, and pharmaceutical usage within the nation. Environmental indicators (H) may consist of variables such as sanitary living conditions, proximity to water bodies, rainfall patterns, and geographical characteristics. Lastly, socio-economic indicators (E) may encompass metrics such as per capita income, educational attainment, migration trends, and others. [24]

In contrast to the conventional production function where output typically escalates with an increase in the quantities of inputs utilized in the production process, the health production function presents a unique scenario. Here, the incidence of morbidity related to specific diseases (for instance, malaria) diminishes as the amounts of inputs allocated for health production are augmented. This phenomenon also manifests when the overall mortality rate is considered as an output variable [24].

2.2. Empirical Literature Review

Ibrahim, V. H. conducted a comprehensive investigation into the intricate relationship between the incidence of malaria, the effectiveness of malaria control measures, and their subsequent impact on health outcomes as well as the development of human capital within the context of Nigeria, covering a substantial span from the year 1991 through to 2017. Utilizing the Vector Error Correction Mechanism as a methodological framework for analysis, the findings indicated that incidence of malaria exerted a positive yet marginal influence on critical health indicators such as the mortality rate of adult, the mortality rate of under-five children, and the overall development of human capital. Furthermore, it was observed that the implementation of malaria control strategies had a positively minimal impact on the reduction of malaria prev-

alence throughout the Nigerian population [10]

Yakum, I. M., Njimanted, G. F., Vukenkeng, A. W., and Nfor, O. N utilized a quantitative research approach to examine the socioeconomic determinants that affect the adoption of malaria prevention strategies among households in the North West Region of Cameroon. Thus, data were collected from a sample of 400 households that were intentionally selected from the ten health districts characterized by the highest incidence of malaria within the North West Region of Cameroon. The analytical framework employed Ordinary Least Squares, Poisson, and Ordered Logit Regression methodologies to clarify the socioeconomic factors influencing malaria prevention behaviors among households. The findings revealed that community-level malaria prevalence, awareness of malaria symptoms, comprehension of malaria etiology, age of household heads, marital status of household heads, household size, costs related to malaria prevention, monthly income of households, educational qualifications, and employment status of the household head constitute socioeconomic variables that significantly affect the malaria prevention decisions made by households in the North West Region [29].

Ahuru, R. and Omon, I. J undertook a comprehensive investigation into the repercussions of Malaria as a considerable health encumbrance on national productivity in Nigeria. Within their examination, Malaria was delineated through both the frequency of Malaria-associated mortalities and the existing prevalence of Malaria infections. Labour productivity was evaluated utilizing Per Capita Income metrics. The annual time series data employed for this analysis encompassed the years from 1987 to 2017 and was obtained from the World Bank Data repository. The stationarity of the variables was scrutinized using the Augmented Dickey Fuller test. Initially, none of the variables exhibited stationarity; however, following first differencing, all variables achieved stationarity, signifying that they are integrated of order one. The Engel-Granger Co-integration test confirmed the existence of a long-term association among the variables. The findings derived from the estimated Error Correction Model suggested that Malaria adversely affected labour productivity, public health expenditure had a negligible influence on per capita income, and the rate of secondary school enrolment negatively impacted labour productivity [4].

Urama, C. E., Manasseh, C. O., and Ukwueze, E. R conducted an examination of the economic implications associated with the treatment of malaria on economically disadvantaged rural households sourced from six communities within Enugu State, utilizing a cost of illness analytical framework. The findings of the study revealed that the 'most affluent' rural households, on average, allocated ₦6153 (28.41%) of their monthly income to malaria treatment, whereas households classified within the lowest income quintile dedicated 30.25% of their average monthly earnings to this healthcare necessity. This scenario engenders considerable financial strain for these households, necessitating the

reduction of expenditures on other vital needs [22]

Ibor, U. W. and Okoronkwo, E. M conducted an examination of the demographic and socioeconomic determinants influencing the prevalence of malaria in Calabar, situated within Cross River State. A total of 300 questionnaires, meticulously designed for the purpose of this investigation, were disseminated to the heads of households. Principal Component Analysis (PCA) was employed on a comprehensive array of socioeconomic data to identify significant demographic and socioeconomic factors that enhance vulnerability to malaria. The outcomes derived from the PCA indicated that housing type (0.816), number of children (0.745), marital status (0.761), and occupation (-0.883) represented the principal socioeconomic variables correlated with malaria vulnerability in the examined region. Collectively, these variables accounted for 68.2% of the overall variance observed within the initial dataset [9]

Adepoju, K. A. and Akpan, G. E conducted an analysis of the historical patterns and irregularities in malaria incidence and associated death in Nigeria spanning 60 years. Findings indicate a marked increase in malaria prevalence from 2000 to 2015, with the majority of cases occurring in children and women. Furthermore, it was noted that the geographical distribution of malaria in Nigeria might undergo a transition towards the North-Central region, influenced by a confluence of environmental, social, and demographic factors [3].

Abah, A. E., Awi-Waadu, G. D. B., Nduka, F. O., and Richard, A. employed a descriptive research methodology to investigate the incidence of malaria and the impact of socio-economic status on individuals residing within the Port Harcourt metropolis. A sample size comprising 200 respondents was utilized for the data analysis. The findings revealed an overall malaria prevalence of 71 cases (35.5%) among the entire sample population. Gender-specific prevalence illustrated that a greater number of males were affected, with 42 cases (40%) and a parasite density of 91120 micro-liters (μ l), in contrast to females, who presented 29 cases (30.5%) and a parasite density of 62480 μ l. The examination of malaria infections concerning socio-economic status indicated that the highest infection rate was observed within the upper class, with 55 cases (38.2%) and a parasite density of 112880 μ l, followed by the lower class, which recorded 12 cases (35.3%) and a parasite density of 29120 μ l, whereas the middle class displayed the lowest infection rate, with merely 4 cases (18.2%) and a parasite density of 11600 μ l [1].

Abatan, S. M. and Batunde, A. utilized a descriptive survey methodology to systematically evaluate the prevalence and trends of malaria occurrences in Ekiti State, Nigeria. They observed that interventions do not invariably result in a reduction of malaria cases across diverse categories of hospitals in Ekiti State; factors such as inadequate sanitation, absence of potable water, insufficient immunization and health education, alongside malnutrition, collectively exacerbated the malaria risk [2].

Nnadu, P. M., Peter, E., Alexander, P., Koggie, A. Z., and

Maikenti, J. I. conducted a comprehensive analysis regarding the incidence of malaria among pediatric patients aged 2-15 who sought medical attention at Gwarinpa General Hospital Life-Camp located in Abuja, Nigeria, utilizing a descriptive survey methodology. The findings of the investigation revealed that 128 children (64%) were diagnosed with infection by the malaria parasite, derived from a sample population of 200 children within the designated age category. It was observed that the youngest age cohort of 2-5 years demonstrated the highest rate of infection (29%), succeeded by the age groups of 6-10 years and 11-15 years, respectively [14].

Nwanosike, D. U., Ikpeze, I. N., and Ugbor, I. K. investigated malaria prevalence and health outcome in Nigeria from 1970 to 2013 using ordinary least square. Findings revealed that malaria cases and public expenditure on health leads to an increase in mortality rate of under-five children, but per capita income and literacy rates leads to reduction in under-five mortality [15].

Nyiatagher, Z. I., Umeh, J. C., and Ocholi, A. employed descriptive statistical methodologies alongside household expenditure frameworks to investigate the ramifications of malaria on household consumption behaviors in North-Central Nigeria. A multistage sampling technique was utilized to collect data from 600 households affected by malaria within this geographical area. The results revealed that only 39% of the households within the studied region were capable of sustaining a three-meal-per-day regimen during episodes of malaria, compared to 61.7% prior to such events. The household expenditure frameworks illustrated a negative correlation between the incidence of malaria and expenditures on food, education, and housing. Additionally, the study established a positive correlation between health-related expenditures of the affected households and factors such as household income, borrowing, asset liquidation, and de-saving practices in North-Central Nigeria [16].

Olalekan, M. S. and Nurudeen, A. S. employed the cost of illness framework in conjunction with primary data analysis to evaluate the trends linked to the burden of malaria and the effectiveness of malaria control measures within the Asa Local Government Area of Kwara State, Nigeria. A total of 1200 households were surveyed utilizing a structured questionnaire for the execution of this analysis. The findings revealed that 37 percent of the population within the study sample had experienced malaria infections, accompanied by a dependency ratio of 33 percent. Moreover, it was determined that the total private direct costs were ₦446.070 billion, while the aggregate private indirect costs reached ₦1,409.790 billion. The study estimated that the overall economic burden of malaria in Nigeria was approximately ₦2,231.34 billion, which represented 7.3 percent of the Gross Domestic Product (GDP) in 2011. Furthermore, the results illustrated a significant reduction in the economic burden of malaria when compared to the baseline study conducted in 2007 [18].

A majority of the analyzed research concentrated solely on the influence of malaria prevalence on households situated in

particular regions within Nigeria, without considering its overall effects, with the exception of [10, 4], as well as [15]; however, these investigations were grounded in time series analysis. This research employs a panel data analysis methodology within English-speaking nations of West Africa and also human development index which is a comprehensive measure was used to capture human development as against [10] who used GDP per capita to capture human development.

3. Methodology

The study adopted the Pooled Mean Group or Panel Autoregressive distributed lag (PMG/PARDL) to examine the objective of the study. The secondary panel data was used for the analysis covering the period from 2000 to 2023. The data on the Anglophone West African Countries which include Nigeria, The Gambia, Sierra Leone, Liberia, and Ghana was obtained from World Development Indicators [25] and United Nations Development Program [21].

In order to rigorously examine the implications of malaria incidence on the advancement of human capital within Anglophone West African nations, the present investigation employs the production function paradigm established by [24], wherein the morbidity associated with a disease is conceptualized as a function influenced by preventive health initiatives, healthcare services, communal environmental factors, and socio-economic determinants, as delineated in Equation [2], thereby refining the empirical research conducted by [10]. The revised production function model posited for this inquiry incorporates variables such as Malaria Incidence, the Adult Mortality Rate (disaggregated by gender), the Under-Five Mortality Rate, and the Human Development Index.

3.1. Model Specification

The model's functional form is presented in equation 3 below.

$$\text{HDI} = f(\text{U5M}, \text{MLI}, \text{ADMF}, \text{ADMM}) \quad (3)$$

Where;

HDI = represent human development index as the dependent variable is proxied for human capital development in Anglophone West Africa countries, U5M represent mortality rates of under-five children, MLI represent incidence of malaria, ADMF denotes mortality rate of female adults, ADMM represent mortality rate of male adults, all form the independent variables.

The functional and econometric forms of the modified model are presented in equations (4):

$$\text{LnHDI}_{it} = \beta_0 + \beta_1 \text{U5M}_{it} + \beta_2 \text{MLI}_{it} + \beta_3 \text{ADMF}_{it} + \beta_4 \text{ADMM}_{it} + e_t \quad (4)$$

Where;

LnHDI represent log of human development index, LnU5M represent log of mortality rate of children under-five (measured per 1,000 live births), LnMLI represent log of incidence of malaria (measured per 1,000 population at risk), LnADMF denotes log of mortality rate of female adults (measured per 1,000 female adults), LnADMM represent log of mortality rate of male adults (measured per 1,000 male adults).

B_0 is the constant; $\beta_1, \beta_2, \beta_3, \beta_4$, are the slopes of the variables; e_i = error or stochastic term; it represents the time dimension (2000–2023).

Therefore, the PMG model used in this study is represented in equation (5)

$$\Delta \text{LnHDI}_{it} = \alpha_0 + \sum_{t=i}^p \varphi_1 \Delta \text{LnHDI}_{it} + \sum_{t=i}^p \varphi_2 \Delta \text{LnU5M}_{it-i} + \sum_{t=i}^p \varphi_3 \Delta \text{LnMLI}_{it-i} + \sum_{t=i}^p \varphi_4 \Delta \text{LnADMF}_{it-i} + \sum_{t=i}^p \varphi_5 \Delta \text{LnADMM}_{it-i} + \alpha_1 \text{LnHDI}_{it-i} + \alpha_2 \text{LnU5M}_{it-i} + \alpha_3 \text{LnMLI}_{it-i} + \alpha_4 \text{LnADMF}_{it-i} + \alpha_5 \text{LnADMM}_{it-i} + \varepsilon_t \quad (5)$$

Where; LnHDI, LnU5M, LnMLI, LnADMF, LnADMM α_0, ε and t are as defined earlier while Δ is operator. The long-term co-integration was evaluated using Equation (6);

$$\Delta \text{LnHDI}_{it} = \alpha_0 + \sum_{t=i}^p \varphi_1 \Delta \text{LnHDI}_{it} + \sum_{t=i}^p \varphi_2 \Delta \text{LnU5M}_{it-i} + \sum_{t=i}^p \varphi_3 \Delta \text{LnMLI}_{it-i} + \sum_{t=i}^p \varphi_4 \Delta \text{LnADMF}_{it-i} + \sum_{t=i}^p \varphi_5 \Delta \text{LnADMM}_{it-i} + \varepsilon_t \quad (6)$$

The determination of the maximum lag length for the PMG (p q) is contingent upon the automated selection of lag intervals. This investigation extracted the short-term dynamic parameters from the estimation of the Error Correction Model (ECM), which is linked to the long-term estimations.

$$\Delta \text{LnHDI}_{it} = \alpha_0 + \sum_{t=i}^p \varphi_1 \Delta \text{LnHDI}_{it} + \sum_{t=i}^p \varphi_2 \Delta \text{LnU5M}_{it} + \sum_{t=i}^p \varphi_3 \Delta \text{LnMLI}_{it} + \sum_{t=i}^p \varphi_4 \Delta \text{LnADMF}_{it} + \sum_{t=i}^p \varphi_5 \Delta \text{LnADMM}_{it} + \delta \text{ECM}_{t-1} + \varepsilon_t \quad (7)$$

Where;

$\varphi_1 - \varphi_6$ is the short-run dynamic coefficients converging to long-run equilibrium and δECM_{t-1} is the speed of ad-

justment parameter and the error correction model are derived from the established equilibrium relationship.

3.2. PMG Estimation Procedure

Before conducting the PMG analysis, there are some pre-estimation tests that was carried out. This includes the Descriptive Statistics Test which considers the mean, the minimum and maximum values, followed by Pairwise Correlation, after which the Cross Section Dependence Test the (CDS) was conducted to investigate whether the variables are cross-sectionally dependent or not. There after the Panel Unit Root Test using CIPS was performed on individual variable to ascertain the order of stationarity. The lag selection was based on automatic selection, and the Panel Co-integration Analysis for the examination of long-term associations among non-stationary variables using either (Kao, Westerlund or Pedronic) was also performed. After the pre-estimation tests, the analysis was achieved through the

use of the PMG, Dynamic fixed effect, Hausman Test.

Afterward, there are some post-estimation tests also known as residual diagnostic tests that was carried out to determine the credibility of the conclusions drawn from the PMG model analysis. These tests include the Heteroscedasticity to check if the series are homoscedastic or not, the Normality test to check if the variables are normally distributed or not. Serial Correlation Test using Breusch Godfrey to check for presence or absence of autocorrelation in the PMG.

4. Results and Discussion

Descriptive statistics helps to have a glimpse of the nature of the data.

Table 1. Descriptive statistics.

	Obs	LnHDI	LnU5M	LnMLI	LnADMF	LnADMM
Mean	120	-0.75601	4.59687	5.70091	5.63625	5.77740
Maxi	120	-0.50418	5.42009	6.13692	5.97563	6.10188
Mini	120	-1.45671	3.71357	3.78041	5.32046	5.41922
Std. Dev	120	0.148859	0.42974	0.45479	0.18578	0.14611

Source: Authors Computation using Stata 15.0, 2024.

Table 1 provides the summary statistics of the effect of malaria incidence on health indices and human development, as elucidated in the results of the summary statistics it is seen that log ADMM has the highest mean value followed by MLI, ADMF, U5M and log HDI has the least mean value and with a negative sign of (-0.75601), this implies that HDI having a negative value shows that some of the west Africa Anglo-phone countries have very low HDI scores, suggesting a sig-

nificant development challenges and this has resulted to worse health outcomes.

The maximum values of all the corresponding variables are greater than the mean value, except for HDI. The small values of the standard deviation suggested that the data for all the west African anglophone nations encompassed within the panel exhibit a considerable degree of dispersion.

Table 2. Pairwise Correlation Analysis.

Summary	LnHDI	LnU5M	LnMLI	LnADMF	LnADMM
LHDI	1.0000				
LU5M	-0.6794	1.0000			
LMLI	-0.3195	0.7338	1.0000		
LADMF	-0.4033	0.7254	0.4075	1.0000	
LADMM	-0.4190	0.7030	0.3887	0.9601	1.0000

Source: Authors Computation using Stata 15.0, 2024.

The above Table 2 correlation result demonstrated that the highest correlation coefficient is between log ADMF and ADMM with value of (0.9601) followed by U5M (0.7338), however, log MLI and HDI has the least correlation coefficient (-0.3195) This implies there is no possibility of multi-collinearity between data set in the panel.

Table 3. CDS Test.

Variables	CD-test	P-Value	Corr	Abs (corr)
LnHDI	13.75	0.000**	0.888	0.888
LnU5M	15.21	0.000**	0.982	0.982
LnMLI	8.99	0.000**	0.581	0.581
LnADMF	7.49	0.000**	0.484	0.545

Variables	CD-test	P-Value	Corr	Abs (corr)
LnADMM	11.89	0.000**	0.768	0.768

Source: Authors Computation using Stata 15.0, 2024. Note: ***, **, * indicate significant at 1%; 5%, & 10%.

From the cross-sectional result in Table 3 above, it is obvious that the null hypothesis cannot be accepted that our data are cross-sectional independent. Therefore, we focused solely on the result from [20] test because of the characteristics of the panel data such that $N > T$. Nevertheless, all the CD test result were all uniform, confirming to the fact that there is cross-sectional dependence on the data. Based on this outcome, the use of second-generation unit root such as Pesaran CIP was incorporated.

Table 4. Pesaran's CIPS Unit Root Test in the presence of CDS.

Variables	Level (t)	1%	5%	10%	1 st Diff (t)	1%	5%	10%	Remark
LnHDI	1.292	-2.21	2.33	-2.57	-5.414	-2.21	-2.33	-2.56	1(1)
LnU5M	-5.477	-2.21	-2.33	-2.57	-2.582	-2.73	-2.86	-3.1	1(0)
LnMLI	-2.591	-2.21	-2.33	-2.57	-1.719	-2.21	-2.33	-2.57	1(0)
LnADMF	-1.982	-2.21	-2.33	-2.56	-5.686	-2.21	-2.33	-2.57	1(1)
LnADMM	1.058	-2.21	-2.34	-2.75	-4.906	-2.12	-2.33	-2.67	1(1)

Source: Authors Computation using Stata 15.0, 2024.

The Pesaran CIPS of constant no trend test result presented in Table 4 above, indicated that log under five mortality rate (U5M), incidence of malaria (MLI), are stationary at level, 1(0), but after conducting the first difference of all the variables, variables such as human development index (HDI), mortality rate, adult female (ADMF) and mortality rate, adult male (ADMM) were found to be stationary at first difference at 1(1), this means that there is a mixed order of integration. [19] opposes the notion that it's possible to use panel ARDL

framework to establish long-run relationship even in situations where the integration among the variables is different, i.e., irrespective of whether the variables are integrated of order 1(0) or 1(1)

Correspondingly, the presence of cross-sectional dependence and the unit root result necessitated the need to employ a test of co-integration that handles the problem. Hence, for the purpose of this study, the Kao co-integration test was adopted to examine co-integration in our variables.

Table 5. Kao Test for Co-integration Test (Kao).

Cointegration vector: Same Panel means: Included Kernal: Barlett Time trend: Not included Lags 1.80 (Newey-West) AR parameter: Same Augmented lags 1. H₀: No cointegration Number of panels = 5 H_a: All panels are cointegrated Number of periods = 22			Statistic	P-Value
Modified Dickey-Fuller t			-3.8402	0.0001
Dickey-Fuller t			-7.4630	0.0000

Cointegration vector: Same Panel means: Included Karmel: Barlett Time trend: Not included Lags 1.80 (Newey-West) AR parameter: Same Augmented lags 1. H₀: No cointegration Number of panels = 5 H_a: All panels are cointegrated Number of periods = 22			Statistic	P-Value
Augmented Dickey-Fuller t			-4.2014	0.0000
Unadjusted modified Dickey-Fuller t			-3.0556	0.0011
Unadjusted Dickey-Fuller t			-7.4256	0.0000

Source: Authors Computation using Stata 15.0, 2024.

Table 5 established the co-integration in the model by using Kao co-integration test, judging by the P-values it is glaring that all the values of (0.0000, 0.0000, 0.0011, 0.0000) are all less than 5% (0.05) level of significance, this means that the null hypothesis of no co-integration is rejected and the alternate is accepted which established there is the existence of

co-integration between human development index and all the independent variables incorporated in the model. The suitable techniques of analysis to be employed is the pooled mean group (PMG), to check for the long- and short-term connection between the variables.

Table 6. PMG-ARDL Long-run and Short run Estimation Outcomes.

D.LHDI	Coefficient	Std.Err	Z-stat	P>(Z)
Long-run Coeff				
LnU5M	-0.0981703	0.0600421	-1.64	0.102
LnMLI	-0.0335905	0.0538252	-0.62	0.533
LnADMF	1.082726	0.2277004	4.76	0.000
LnADMM	-1.492547	0.2651199	-5.62	0.000
Error Correction Coefficient (EC)	-0.235488	0.1289398	-1.82	0.054
Short-run Coefficient				
D. LnU5M	0.035467	0.138411	0.26	0.013
D.LnMLI	0.0792304	0.047535	1.67	0.096
D.LnADMF	0.0572234	0.0890451	-0.64	0.520
D.LnADMM	0.1622885	0.2182408	0.74	0.457
Intercept	0.5815202	0.3113574	1.87	0.062
Observation	115	115	115	115

Source: Authors Computation using Stata 15.0, 2024. Note, ***, **, * is statistically different from zero at 1%, 5%, and 10% significance level, respectively, the lag structure is ARDL (1,0001) and is determined by the Akaike information criterion (AIC).

The result in the long run of log under five mortality rates (U5M), incidence of malaria (MLI) was having an inverse effect on log of human development index (HDI), and they are also found not to be statistically significant at 5% level. This is in contrast to the study carried out by [10] whose result provided that the incidence of malaria exerted a positive yet marginal influence on critical health and the overall devel-

opment of human capital.

However, the short-run of both U5M and HDI, is in contrast to the long-run impact which was found to have a positive relationship with HDI, although U5M on the other hand is found to be statistically significant at 5% level, unlike MLI which was still not statistically significant, this is in agreement with [10, 4, 15].

In the both long run and short run log mortality rate, adult female (ADMF) and male adult mortality rates (ADMM) are having a positive impact on HDI, although in the long run they were all statistically significant at the 5% level, this implies that high mortality rates in both male and female might have prompted increase investment in healthcare, leading to improved HDI, also for the positive effect of ADMF and ADMM on HDI signifies that in the Anglophone west Africa countries such as Nigeria, Ghana, Gambia, Sierra Leone and Liberia might stimulate economic growth through increased labour productivity or remittance, consequently, this align to the [24] theory of health production function. But the outcome in the long-run shows that they were not statistically significant. This implies that both mortality rates (ADMF & ADMM) have reached a long-run equilibrium, where changes in mortality rates no longer significantly affect HDI.

The error correction term (ECT) met the three criteria of having a negative coefficient and less than one and been significant with P-value less than 0.05 level of significant. The EC is approximately -0.23 suggesting that any deviations from the long-term equilibrium is adjusted at the 23% adjustment speed from 2000 to 2023. The EC is significant at 5% significant level implies a significant long-term co-integration, also demonstrate that we can infer joint causality of the variables, i.e. all the variables log (U5M, MLI, ADMF and ADMM) jointly influence the endogenous variable log (HDI) in the long-run.

Table 7. Dynamic Fixed Effect Estimation Outcomes.

D.LHDI	Coefficient	Std.Err	Z-stat	P>(Z)
Long-term Coeff				
LnU5M	-0.3941921	0.1832512	-2.15	0.031
LnMLI	0.0345617	0.0296105	1.17	0.243
LnADMF	-0.8480715	0.868018	-0.98	0.329
LnADMM	-0.6281459	0.970762	0.65	0.518
Error Correction Coefficient (EC)	-0.2893445	0.1413445	-2.75	0.006
Short-run Coefficient				
D.LnU5M	-0.8761567	0.588787	-1.49	0.137
D.LnMLI	-0.0901626	0.0594991	0.120	0.056
D.LnADMF	-0.0671926	0.1832804	-0.37	0.714
D.LnADMM	-0.5218162	0.5942647	0.88	0.380

Source: Authors Computation using Stata 15.0, 2024.

From the result of the dynamic fixed effect, we can infer

that all that variable such as log of mortality rates of under-five children (U5M), mortality rates of female adults (ADMF) and mortality rate of male adults (ADMM) are all having a negative effect on human development index (HDI) and are all insignificant at the 5% level of significant, except for LU5M which is significant at 5% level with P-value of (0.031) which is less than the level of significance. For log incidence of malaria (MLI) it was found to have a positive and insignificant effect on HDI.

The coefficient of the error correction term is found to have a negative sign of (-0.28), this reveals the speed of convergence to long-term equilibrium to around 28% per year from 2000 to 2023 and it is highly significant with p-value of (0.006) which is significant at the 5% level.

Table 8. Hausman Test.

	(b) DFE	(B) pmg	(b-B) Difference
LnU5M	-0.1774507	-0.0981702	-0.079804
LnMLI	-0.0203758	-0.0335905	0.0132148
LnADMF	0.1508138	1.082726	-0.9319118
LnADMM	0.1508138	-1.492547	1.10821
Prob)chi2	0.00	1.0000	

Source: Authors Computation using Stata 15.0, 2024.

The Table 8 above of the Hausman test enables us to have a check to know whether we employ the right estimator in our model. Since the p-value of the Hausman test is 0.00 which is less than the 5% level, it means that the dynamic fixed effect and the pooled mean group are the right estimator that we apply in the model. Thus, based on the Hausman test, the DFE and the PMG model, in which malaria incidence on health outcomes jointly affect the human capital development proxied by human development index (HDI) in west Africa.

Table 9. Post estimation test.

Test	Chi2	P>value
Breusch-Pagan LM	74.220	0.1000
Normality (Skewness)	0.0679	0.0195
Normality (Kurtosis)	0.0203	0.0195

Source: Authors Computation using Stata 15.0, 2024.

Table 9 above shows all the post estimation test of both heteroscedasticity test using the Breusch-Pagan LM and the Normality test for (skewness and kurtosis). The P-value of the

Breusch Pagan LM which is greater than 5% level shows that there is no occurrence of heteroscedastic and that the series are homoscedastic.

For the normality test for both joint skewness and kurtosis the p-values of the series are all less than the 5% level, this implies that we reject the null and accept the alternative which states that our series are normally distributed.

5. Conclusion and Recommendations

The research examines the effect of malaria incidence on health outcomes and human capital development in Africa, with focus on Anglophone countries in West Africa such as Nigeria, Gambia, Ghana, Sierra Leone and Liberia over the period 2000 to 2023. The study employed panel data econometric techniques such as cross sectional dependency, thereafter, the second generation unit root test was used such as Pesaran CIP the outcome of the CDS test determines the choice of the second generation unit root test, then the co-integration test such as Kao was employed since there is the existence of co-integration in the model this led to the adoption of the pooled mean group, or the panel ARDL which gives us the short run and long run effect of the independent variables on the dependent variable.

The empirical analysis of the PMG revealed that log under five mortality (U5M), incidence of malaria (MLI), and mortality rates adult male (ADMM) are having a negative effect on human development index (HDI) and health outcome, but only ADMM was significant to HDI, while mortality rates adult female (ADMF) was having a positive and insignificant effect on HDI. Similarly in the short run they were all having a positive effect on HDI, but only U5M is having a positive significant effect on HDI. Moreover, the findings indicates that malaria incidence hinders human capital development in these Anglophones countries by reducing educational absenteeism, and decreasing productivity. The results underscore the critical needs for effective malaria control and elimination strategies to improve health indices and promote human development in Africa.

All post diagnostic test shows that the model is free from heteroscedasticity rather they are homoscedastic and the series are normally distributed. Therefore, the study put forth the recommendations.

The Anglophone west Africa countries should prioritize investments in malaria prevention, diagnosis and treatment, as well as integrate malaria control programs into broader health and education policies.

The government should ensure that the health sector promote interdisciplinary research on malaria and human capital development.

These countries should scale up malaria prevention and control programs.

There should be increased access to quality education and health care in rural and urban areas, focus should be on mostly the younger ones since they are susceptible to malaria infection.

Abbreviations

ADMM	Adult Male Mortality Rate
ADMF	Adult Female Mortality Rate
CDS	Cross Sectional Dependence
HDI	Human Development Index
MIS	Malaria Indicator Survey
MLI	Incidence of Malaria
μl	Microliters
PARDL	Panel Autoregressive Distributed Lag
PMG	Panel Pooled Mean Group
U5M	Mortality Rate of Under-five Children

Author Contributions

Ameji Enemona Ngedu: Conceptualization, Data curation, Writing – original draft, Writing – review & editing

Charity Philip Sidi: Formal Analysis, Methodology, Software

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Abah, A. E., Awi-Waadu, G. D. B., Nduka, F. O., and Richard, A. (2017). Malaria infection and socio-economic status of some residents of Port Harcourt metropolis, Rivers State, Nigeria. *Journal of Applied Science, Environment and Management*, 21(2), 299-304. <https://doi.org/10.4314/jasem.v21i2.10>
- [2] Abatan, S. M. & Batunde, A. (2015). Empirical investigation into the patterns and trends of occurrences of malaria cases in Ekiti State, Nigeria: an analysis of the skewed ARMA. *International Journal of Banking, Finance, Management and Development Studies*, 3(1), 163-186.
- [3] Adepoju, K. A. & Akpan, G. E. (2017). Historical assessment of malaria hazard and mortality in Nigeria-cases and deaths: 1955-2015. *International Journal of Environment and Bioenergy*, 12(1), 30-46. <http://www.modernscientificpress.com/Journals/IJEE.aspx>
- [4] Ahuru, R. & Omon, I. J. (2018). The economic burden of malaria: Evidence from Nigeria's data. *Amity Journal of Healthcare Management*, 3(1), 28-39.
- [5] Brems, H. (1968). *The production function: quantitative economic theory*. New York: Wiley, 62-74.
- [6] Carrington, A. (2001). Malaria: it's human impact, challenges, and control strategies in Nigeria. *Harvard Health Policy Review*, 2(2).
- [7] Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy*, 80(2), 223-235. <https://doi.org/10.7312/gros17812-004>

- [8] Hulton, C. R. (2000). Total factor productivity: a short biography. *NBER Working Paper No. 7471*.
- [9] Ibor, U. W. & Okoronkwo, E. M. (2017). Demographic and socioeconomic factors influencing malaria incidence in Calabar, Cross River State, Nigeria. *Science World Journal*, 12(3), 19- 24. <http://www.scienceworldjournal.org/>
- [10] Ibrahim, V. H. (2021). Effect Of Malaria Incidence and Malaria Control on Health Outcome and Human Capital Development in Nigeria: An Econometric Analysis. *Journal of Economics and Allied Research Vol. 6(1)*, 69-89.
- [11] Jimoh, A., Sofola, O., Petu, A., and Okorosobo, T. (2007). Quantifying the economic burden of malaria in Nigeria using the willingness to pay approach. *Cost Effectiveness and Resource Allocation*, 5(6), 1-8.
- [12] Malaria Indicator Survey (MIS) (2015). *Nigeria malaria indicator survey for 2015: final report*. Abuja, Nigeria.
- [13] National Population Commission (NPC) (2022). *Statistics*. Retrieved on June 12, 2022 from www.nationalpopulation.gov.ng
- [14] Nnadu, P. M., Peter, E., Alexander, P., Koggie, A. Z., and Maikenti, J. I. (2015). The prevalence of malaria in children between the ages 2-15 visiting Gwarinpa general hospital life-camp, Abuja, Nigeria. *Journal of Health Sciences*, 5(3), 47-51. <https://doi.org/10.5923/j.health.20150503.01>
- [15] Nwanosike, D. U., Ikpeze, I. N., and Ugbor, I. K. (2015). Investigation of malaria prevalence and health outcome in Nigeria. *ISOR Journal of Humanities and Social Science*, 20(5), 79-84. <https://doi.org/10.9790/0837-20517984>
- [16] Nyiatagher, Z. I., Umeh, J. C., and Ocholi, A. (2015). Socio-economic effects of malaria on households' consumption in north-central Nigeria. *IOSR Journal of Agriculture and Veterinary Science*, 8(7), 65-72.
- [17] Ogiri, A. E. (2017). *Much ado about the 2018 health budget*. Blueprint Newspapers Limited.
- [18] Olalekan, M. S. & Nurudeen, A. S. (2013). Malaria burden and the effectiveness of malaria control measures in Nigeria: a case study of Asa local government area of Kwara State. *Journal of Economics and Sustainable Development*, 4(3), 295-308.
- [19] Pesaran and Shin (1999). Bound testing approaches to the analysis of level relationship. *Journal of Applied Econometrics*, 16(13): 289-326. <https://doi.org/10.1002/jae.616>
- [20] Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. *Cambridge working papers in economics*, No.0435.
- [21] United Nations Development Programme (UNDP). (2023). <https://hdr.undp.org/data-center/human-development-index#/indicies/HDI>
- [22] Urama, C. E., Manasseh, C. O., & Ukwueze, E. R. (2018). The economic cost of malaria treatment to poor rural households in selected communities in Enugu State. *Journal of Economics and Allied Research*, 2(2), 1-17.
- [23] Wagstaff, A. (1986). The demand for health: theory and application. *Journal of Epidemiology and Community Health*, 40(1), 2. <https://doi.org/10.1136/jech.40.1.1>
- [24] Wibowo, D. and Tisdell, C. (1992). Health production function for preventive health programs. *Proceedings of the Fourteenth Australian Conference of Health Economists*, p. 106-133, Faculty of Economics, Commerce and Management Monash University and National Centre for Health Program Evaluation Fairfield Hospital.
- [25] World Bank Development Indicator (WDI) (2023). <https://databank.worldbank.org/source/world-development-indicators>
- [26] World Health Organization (WHO) (2016). *World malaria report 2016*. Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789241511711>
- [27] World Health Organization (WHO) (2020). Malaria. Retrieved from www.who.int/news-room/fact-sheets/detail/malaria
- [28] World Malaria Report (2020). *20 years of global progress and challenges*. Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789240015791>
- [29] Yakum, I. M., Njimanted, G. F., Vukenkeng, A. W., & Nfor, O. N. (2020). Socioeconomic determinants of malaria prevention options adoption of households in the North West Region of Cameroon. *International Journal of Health Economics and Policy*, 5(2), 15-30. <http://www.sciencepublishinggroup.com/j/hep>
- [30] Yelwa, M. and Diyoke, K. O. (2014). Empirical analysis of the incidence of malaria on human capital development and economic growth in Nigeria. Retrieved from www.researchgate.net/publication