PREVALENCE OF MALARIA AND INFANT MORTALITY IN KOGI STATE, NIGERIA

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Abstract
This study adopts a descriptive survey research design with a quantitative approach to examine the impact of malaria prevalence on infant mortality in selected local government areas across all three senatorial districts of Kogi State, Nigeria. The study covers Lokoja and Ajaokuta LGAs from the Central district, Omala, Igalamela-Odolu, Ibaji, and Bassa LGAs from the East district, and Kabba/Bunu LGA from the West district. These local government areas were selected based on their proneness to flooding and the presence of rivers nearby. Utilising a randomly selected population, data was collected through structured questionnaires and analysed using Binary Logistic Regression. While the results indicate a positive relationship between malaria prevalence and infant mortality, the statistical significance is not established. The study underscores the financial and economic burden associated with malaria treatment, transportation, and prevention, suggesting the need for a comprehensive approach to public health challenges. Policy recommendations include improving healthcare accessibility, promoting awareness campaigns, implementing targeted subsidies for antimalarial medications, and enhancing public transportation services to facilitate easier access to medical facilities.

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Introduction

The prevalence of malaria and infant mortality rate are critical health indicators that significantly impact the well-being of populations, particularly in developing countries. According to the World Health Organisation (WHO) (2022), an estimated 247 million new malaria cases and 619,000 deaths were recorded globally in 2021. In addition, only 4 countries – Nigeria (27%), the Democratic Republic of Congo (12%), Uganda (5%) and Mozambique (4%) account for almost half of all cases globally and of all malaria deaths, 95 per cent occur in the WHO African region alone which include Nigeria, Congo, Uganda, Mozambique, Angola, Burkina Faso, Niger, Tanzania, Mali, Cote d'ivore, Cameroon, Ghana, Benin, Madagascar, Guinea, Malawi, Ethiopia, Burundi, Zambia, Chad, Kenya, South Sudan, Sierra Leone, Togo, Liberia, Central African Republic, Rwanda, Democratic Republic of the Congo, Senegal, Gabon, Equatorial Guinea, Zimbabwe, Guinea-Bissau, Gambia, Eritrea, Mauritania, Namibia, Comoros, South Africa, Sao Tome, Botswana, Eswatini, and Cabo Verde (WHO, 2022). Malaria in humans which is globally known as a major health concern has six plasmodium subspecies namely Plasmodium falciparum, Plasmodium ovale, Plasmodium vivax, Plasmodium malarie, and Plasmodium knowlesi which is transmitted through the bite of infected mosquitoes (FMOH, 2017). Plasmodium falciparum happens to be the most predominant species of the malaria parasite in Nigeria with 97 per cent of the total population at risk (FMOH, 2017). It affects approximately 40 per cent of the world's population, with substantial morbidity and mortality concentrated in 107 high-risk areas, primarily in sub-Saharan Africa (WHO, 2016).

The disease claims millions of lives each year, particularly affecting vulnerable populations in low-income countries.

According to the World Health Organisation (WHO, 2022), Nigeria bears a significant burden of malaria, accounting for 27 per cent of global morbidity and 24 per cent of mortality attributed to the disease. The impact is particularly severe in the WHO African region, with countries like Nigeria, the Democratic Republic of Congo, Uganda, and Mozambique collectively contributing to almost half of all global malaria cases and deaths. Notably, 95 per cent of malaria-related deaths occur in the WHO African region, emphasising the disproportionate impact on African nations (WHO, 2022a).

Malaria is often referred to as the "epidemic of the poor," as it disproportionately affects those who are less able to afford prevention and treatment measures. The disease not only causes immense human suffering but also imposes significant economic costs, affecting both families and national economies. In sub-Saharan Africa, including Nigeria, the impact of malaria is exacerbated by factors such as poverty, limited access to healthcare services, and inadequate living conditions (Nitin, 2021).

Infant mortality, defined as the number of deaths of infants under one year of age per 1,000 live births, is one of the crucial indicators of a nation's overall health status. Malaria contributes significantly to infant mortality, emerging as a leading cause of death in many countries. In 2017, Nigeria reported an infant mortality rate of 73 per 1,000 live births, surpassing the global average (World Bank, 2020b). The state-level disparities within Nigeria are evident, with Kogi State recording the highest infant mortality rate in the country at 93 per 1,000 live births in 2018 (National Bureau of Statistics, 2019).

Extensive research suggests a connection between the prevalence of malaria and infant mortality rates in Nigeria, with a particular focus on Kogi State. Studies in Nigeria have indicated that households who have access to improved health facilities, generally experience improved health outcomes including reduced malaria prevalence, thereby contributing to a lower infant mortality rate (Babalola, Omeonu, Osuntade, Julius & Kalu, 2021; Hauwa, 2021; Abdullahi, Ogbalu & Shigaba, 2020; NCREL, 2010). However, issues persist in Kogi State, specifically concerning the prevalence of malaria and its impact on infant mortality.

Despite the Nigerian government's efforts to mitigate these issues through initiatives like the National Primary Health Care Development Agency (NPHCDA) and the National Malaria Elimination Program (NMEP), the prevalence of malaria and infant mortality rates in Kogi State remains high (Oyibo et al., 2020a/2020b; Abdullahi, Ogbalu & Shigaba, 2020). This is attributed to inadequate funding, limited healthcare infrastructure, lack of rural healthcare access, insufficient health education, and challenges in policy implementation and enforcement (Abdullahi, Ogbalu & Shigaba, 2020). Lack of political willingness and socioeconomic disparities further hinder the success of these government programs (Hauwa, 2021).

Studies in developed countries have extensively explored the link between malaria prevalence and health outcomes (Adler & Rehkopf, 2008; Schellenberg et al., 2003), while attention to health inequities in infectious diseases like malaria in developing countries has been limited. However, the impact of malaria prevalence on key health outcomes such as infant mortality rate in Kogi State remains a gap in the literature.

Given the above, this study aims to investigate the impact of the prevalence of malaria on infant mortality in Kogi State. The objective is to provide valuable insights into how the burden of malaria contributes to infant mortality in selected urban and rural areas of Kogi State. The rest of the paper dwells on the study area of Kogi State, literature review and theoretical framework, methodology, presentation and discussion of results, conclusion and recommendations.

Study Area of Kogi State

The study is conducted in Kogi State. Kogi State, located in the North Central Geo-Political Zone of Nigeria, was established on August 27, 1991, with Lokoja as its capital. The state comprises three senatorial districts (Western, Eastern, and Central) and has 21 LGAs, spanning latitudes 6°30 'N to 8°48 'N and longitudes 5°23 'E to 7°48'E, covering a total land area of 29,833Km2. It shares borders with 10 other Nigerian states and is known for its major ethnic group, the Igala, residing in the East of the Niger. The economy is primarily agriculture-based, contributing around 80 per cent to employment (Onuche, Opaluwa, & Edoka, 2014).

Kogi State in Nigeria has favourable soil conditions and climate for both livestock and crop production. It has a wide stretch of arable land, good grazing grounds, and ample water bodies for fishing. Major crops grown in the state include yams, cassava, rice, sorghum, beans, maize, and cotton (Ibrahim, David & Shaibu, 2017). The state experiences two distinct seasons, the wet season from mid-April to October, and the dry season from November to March, with a reasonable temperature range of 50C - 70C (Onuche, Opaluwa and Edoka, 2014). The maximum temperature is typically in March and April, while the minimum is in December and January. The yearly rainfall lasts for six to eight months, supporting the life cycle of mosquitoes, which are vectors for malaria (Unekwu, 2010). Malaria transmission is aided by the climate and water bodies in the state. The study focuses on seven local government areas (LGAs) that are prone to flooding and have rivers nearby, including Lokoja, Ajaokuta, Omala, Igalamela-Odolu, Kabba/Bunu, Ibaji, and Bassa. The research will be conducted in three villages in each selected LGA. The population of Kogi State is 3,314,043 based on the 2006 census figures (NPC, 2006).

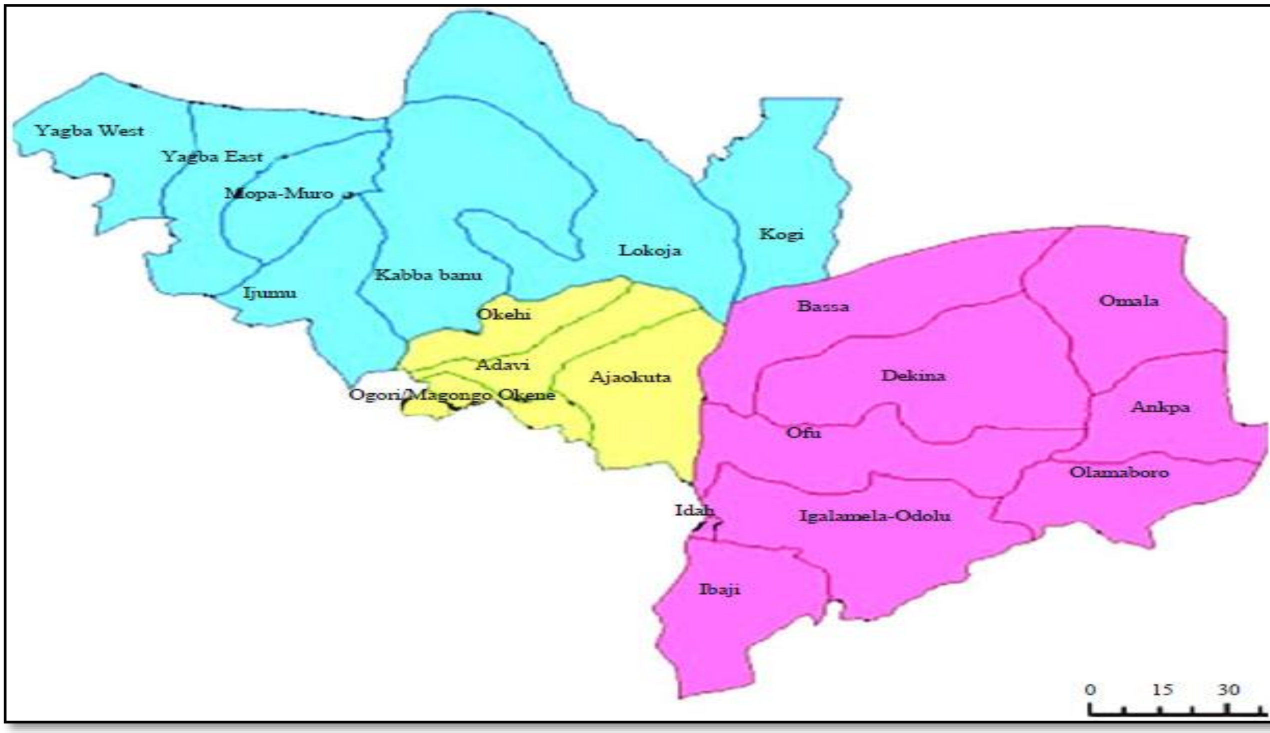

Figure 1: Map of Kogi State Showing the Study Areas
Source: www.nigerianmuse.com

Literature Review

Theoretical framework

This study is anchored on the Health Production Function (HPF) theory propounded by Grossman in 1972. The Health Production Function (HPF) theory, introduced by Grossman (1972), offers an economic perspective on the relationship between inputs and outputs in health production. Similar to traditional production functions in economics, which examine inputs and outputs in the production of goods and services, the HPF theory focuses on the inputs necessary for generating and maintaining good health.

Grossman (1972) proposed that individuals invest in their health, akin to investments in other forms of human capital, accordingly health is not solely determined by genetic factors or luck; rather, it can be influenced by personal choices and investments. The HPF theory is expressed mathematically as:

$$H = f(I, G, E) \quad (1)$$

Where H is health, I is investments in health, G is genetic endowments, and E is environmental factors. Grossman's model emphasises two types of investments in health: Personal Investments, involving actions like regular exercise, healthy diets, and preventive care; and Medical Care Investments, encompassing healthcare services for diagnosis, treatment, and management of health conditions.

Beyond investments (I), the HPF model considers the impact of genetic endowments (G) and environmental factors (E) on health outcomes. Genetic endowments refer to inherent characteristics influencing susceptibility to diseases, while environmental factors include physical, social, and economic influences that can positively or negatively affect health. The HPF theory posits that these inputs interact to produce health outcomes, recognising the complexity of health influenced by various factors. Researchers use econometric techniques to analyse relationships between inputs and health outcomes, aiming to understand contributions and assess intervention efficiency.

In summary, the HPF theory serves as a valuable framework for comprehending the intricate dynamics of health production. It underscores the significance of personal choices, environmental factors, and healthcare services in shaping health outcomes, informing evidence-based strategies for promoting population health and well-being. According to Grossman's model, education plays a crucial role in enabling individuals to increase the marginal productivity of inputs into health production. In the context of this study, education can influence the adoption of preventive measures against malaria, seeking timely medical care, and overall health-seeking behaviours, which can subsequently impact the prevalence of malaria and infant mortality rates.

Empirical review

Anjorin, Okolie and Yaya (2023), analyse the impact of socioeconomic factors on malaria prevalence in under-five children across 11 Sub-Saharan African countries using 2010-2020 Demographic and Health Survey data. Key findings reveal a 24.2 per cent malaria prevalence, increasing with age. Significant factors include maternal education, household wealth, and region. Children of mothers with secondary education show a 56 per cent lower risk, while those in the richest households have a 73 per cent lower risk compared to the poorest, emphasising the crucial role of maternal education in predicting malaria prevalence in this context.

Affiah, Fadoju, James, James, Uzoma, Opada and Jasini (2022) explored the economic implications of malaria treatment and household health-seeking behaviour in Akwa Ibom State, South-South Nigeria. The cross-sectional descriptive research involved 640 households across three Local Government Areas. Utilising quantitative methods, the researchers employed SPSS software to analyse data. The cost of malaria treatment was determined using the prevailing interbank exchange rate of 197 Naira per USD in 2015 and 379 in 2021. Results indicated that 55.7 per cent of households preferred drug stores for malaria treatment. The total cost comprised 44.7 per cent direct and 55.3 per cent indirect costs. The average direct cost per household for malaria treatment was 8,563.77 Naira (22.60 USD), while the average indirect cost was 10,437.09 Naira (27.54 USD). The average total cost per malaria episode was ₦9,305.51 (22.55 USD), and at the household level, the average total cost was 18,868.10 Naira (49.78 USD).

Oluwatimilehin, Akerele, Oladeji, Omogbehin and Atai (2022) examined the impact of climate change on malaria, pneumonia, meningitis, and cholera in Lokoja City, Nigeria. The study aimed to analyse the spatial distribution, prevalence, and coping strategies for these diseases. Data from 2000 to 2020 on rainfall and temperature were sourced from NASA, while medical records came from the Kogi State Ministry of Health. A semi-structured questionnaire surveyed 250 residents who had experienced one of these diseases to investigate coping strategies. Pearson correlation and multiple regression analyses revealed annual variations in climatic parameters, with R^2 values of 0.0557, 0.0009, and 0.4915 for rainfall, maximum and minimum temperatures, respectively. Positive and significant relationships were found between maximum temperature and malaria, rainfall and malaria, minimum temperature and meningitis, and rainfall and cholera. Malaria cases were highest in Ward A (15,422), pneumonia cases peaked at 715 in Kupa North, cholera cases reached 3,787 in Ward A, and meningitis cases were highest in Kupa North (2,383). The investigation indicated that malaria is more prevalent in the wet season, while cholera and meningitis cases peak during the dry season.

Opaluwa, Opeyemi, David and Ochimana (2022) investigated the impact of malaria on maize productivity in Idah Local Government Area, Kogi State, Nigeria, using primary data collected from 120 respondents through a multi-stage random sampling technique. Descriptive statistics and Ordinary Least Squares regressions were employed for data analysis. The findings revealed that 77.5 per cent of the respondents were male, with an average age of 50. The mean household size was 9 members, and 47.50 per cent had access to credit facilities. Factors contributing to malaria incidence included proximity to bushes (77.5%), living near a river (45.83%), working during sunny hours (45.83%), and residing close to stagnant water (40.0%). Common malaria symptoms among farming households included headache (92.5%), body pain (89.17%), tiredness (82.50%), heat (81.67%), and coldness (67.5%). The OLS multiple regression indicated that both day's incapacitation and the frequency of malaria illness were statistically significant at 1 per cent, leading to the conclusion that malaria significantly affected maize productivity in the study area.

Gooch, Martinez-Vazquez and Yedgenov (2021) explored the impact of malaria endemicity in 1900 as an alternative instrumental variable for institutional development in various countries, encompassing European and non-European colonies, as well as nations without colonial history. Their comprehensive analysis revealed a significant link between endemicity in 1900 and regulatory quality in 2000. By examining population and cropland in 1900, they established a statistically significant relationship between endemicity and regulatory quality. Subsequently, their two-stage analysis demonstrated that regulatory quality significantly influenced income in regions where mosquito-borne diseases affected regulatory quality. Moreover, they found that endemicity in 1900 played a role in institutional development for certain countries, particularly those on the margin, referred to as treatment compliers, irrespective of their geographic attributes. The study concluded that, in low-disease environments, quality institutions could have developed independently of European colonisation.

Babalola, Omeonu, Osuntade, Julius and Kalu (2021) investigated the link between infant mortality rate and government expenditure on malaria (GEM), serving as a proxy for health policy. They included per capita income, infrastructure development index (IDI), and government expenditure on education and health as control variables. Data from 1990 to 2019, sourced from the World Bank and African Development Bank database, were used. Unit root tests revealed non-stationarity at the first difference for all variables. Co-integration tests indicated a long-run equilibrium relationship, leading to the adoption of the Error Correction Model. Results from the model's estimated coefficients demonstrated that both IDI and GEM significantly decrease infant mortality rate at a significance level of $p < 0.05$.

Carrasco-Escobar, Fornace and Benmarhnia (2021) utilised data from malaria surveys in Sub-Saharan Africa (SSA) to assess spatial trends in socioeconomic inequalities. They focused on mothers' highest educational level (MHEL) and wealth index (WI) as indicators, calculating the Slope Index of Inequality (SII) and Relative Index of Inequality (RII) for each region. Cluster analyses using the Local Indicator of Spatial Association (LISA) considered spatial auto-correlation. The study included 47,404 participants in 1,874 Primary Sampling Units across 13 SSA countries, revealing significant socioeconomic inequalities within and between countries. Eastern African nations exhibited higher median SII and RII in malaria prevalence relative to WI compared to other SSA regions, with notable pockets of high SII in the East.

Sarpong and Bein (2021) examined the impact of global funds and good governance on malaria incidence and quality of life in sub-Saharan Africa from 2005 to 2017, using panel data. They employed the Generalised Method of Moment (GMM) estimation. Results showed a negative correlation between global funds and quality of life in non-oil-producing countries, while oil-producing countries exhibited a strong positive correlation. Global funds demonstrated a negative association with malaria incidence in both economies, with a stronger effect in oil-producing countries. Good governance had a significant negative correlation with malaria incidence in non-oil-producing countries and a strong positive correlation in oil-producing countries. Additionally, good governance positively correlated with quality of life in both oil and non-oil-producing countries, particularly robust in non-oil-producing nations.

Sede and Ayegbeni (2021) examined the impact of monetary policy on malaria outcomes in Nigeria using time series data from 1991-2018. Descriptive statistics and Augmented Dickey-Fuller unit root tests were conducted on the data, revealing normal distribution and integration of order I(1). The Engle and Granger two-stage Co-integration technique confirmed a long-run relationship between variables. Autoregressive Distributed Lag (ARDL) Error Correction Model (ECM) techniques were employed to analyse short-run dynamics. Results indicated that money supply, as a proxy for monetary policy, had a significant negative effect on malaria outcomes in the long run. The poverty rate exhibited a significant positive impact on malaria outcomes in both short and long-run periods. Literacy rate and economic growth demonstrated mixed effects on malaria outcomes throughout the study period.

Hauwa (2021) investigated the impact of malaria incidence and control on health outcomes and human capital development in Nigeria from 1991 to 2017. The study utilised the Vector Error Correction Model (VECM) to analyse the relationship between malaria incidence and adult mortality rate, under-five mortality rate, and human per capita income. Additionally, it assessed the effect of malaria control measures, such as children receiving anti-malarial drugs, government health expenditure, and insecticide-treated bed nets (ITNs), on malaria incidence in Nigeria. The findings indicated that Nigeria, along with other African nations, has not fully achieved the goal of reducing the malaria burden and effectively controlling its prevalence. The VECM analysis revealed a modest positive impact of malaria incidence on adult mortality rate (0.5%), under-five mortality rate (0.8%), and human per capita income (40%). Furthermore, the study found that malaria control efforts had a positive but limited effect in reducing malaria prevalence in Nigeria.

Abdullahi, et al (2020) evaluated the Roll Back Malaria program in Idah, Kogi State, Nigeria. Data was collected through questionnaires and the Health Information Management System Unit of Idah LGA and analysed using tables and simple percentages. The study found prevalent mosquito species (Anopheles gambiae, Culexquinquefaciatus, Aedeseagypti, and Aedesalbipictus) in the area. Inhabitants used insecticide-treated nets (I.T.N) provided free by the government, resulting in reported malaria cases. Children had a significantly higher malaria incidence (64.7%) than pregnant women (22.6%) and others (12.7%).

Hauwa, Rabo and Ahmed (2020) investigated the impact of malaria incidence and control on health outcomes and human capital development in Nigeria from 1991 to 2017. They employed the Vector Error Correction Model (VECM) to analyse the study objectives: 1) to assess the influence of malaria incidence on adult mortality rate, under-five mortality rate, and human per capita income in Nigeria, and 2) to examine the impact of malaria control on malaria incidence in Nigeria. The study revealed that Nigeria, like other African nations, has not fully achieved the goal of reducing the malaria burden and effectively controlling its prevalence. The VECM analysis indicated a positive but minimal effect of malaria incidence on adult mortality rate (0.5%), under-five mortality rate (0.8%), and human per capita income (40%). Additionally, the analysis showed that malaria control measures, including children receiving anti-malarial drugs, government health expenditure, and insecticide-treated bed nets (ITNs), had a positive effect on malaria prevalence in Nigeria.

Yakum, Njimanted, Vukenkeng and Nfor (2020) employed a quantitative approach to investigate the socioeconomic factors influencing the adoption of malaria prevention measures by households in Cameroon’s North-West Region. They gathered data from 400 purposively selected households in the top ten health districts with high malaria prevalence. The study utilised Ordinary Least Square, Poisson, and Ordered Logit Regression techniques to analyse the socioeconomic determinants of households' malaria prevention behaviour. The research aimed to ensure result robustness through different methodologies. The findings highlighted various factors, including community-based malaria prevalence, knowledge of malaria signs and causes, age and marital status of household heads, household size, cost of prevention, monthly income, education, and employment status, as key determinants shaping households’ malaria prevention choices in the North-West Region.

A survey conducted by Ogomaka (2020) at Imo State University, Owerri examined malaria prevalence and prevention among 618 off-campus students aged 18-27+. Results showed 78.3 per cent had malaria parasites, with the highest (82.1%) in the 23-26 age group and the lowest (71.4%) in the 27+ age group. Males (90.00%) were more infected than females (69.4%). Students using window and door nets had the highest prevalence (90.6%), while insecticide-treated bed nets users had the least (64.7%). Proximity to refuse dumpsites correlated with higher infections (96.3% close, 58.8% far). Data analysis indicated significant malaria prevalence differences based on gender and preventive measures ($p<0.05$), but not age groups ($p>0.05$).

Hauwa, et al (2020) examined the impact of malaria on food security in Kogi State. The study adopted descriptive methods to carry out the analysis. The data were obtained through a household survey conducted between May and August 2020 using copies of the questionnaire. The analysis of the results showed that while the incidence of malaria; direct cost of malaria; and size of family hurt food security (calorie intake), the level of education hurts calorie intake in Kogi state.

While some studies in the review touched on health outcomes, there is a notable gap in the literature specifically addressing the impact of malaria prevalence on the infant mortality rate in Kogi State. Infant mortality is a critical health indicator, and understanding the direct link with malaria is essential for targeted interventions.

Additionally, studies on malaria in Kogi State focused on a specific Local Government Area (LGA), neglecting other LGAs prone to flooding, which is a conducive environment for mosquito breeding. This study aims to investigate 7 LGAs with rivers, susceptible to flooding, creating an ideal habitat for malaria parasites.

Many studies in the review primarily rely on descriptive statistics or simpler regression models. A new study focusing on the impact of malaria on infant mortality rate in specific LGAs could benefit from more advanced statistical techniques, such as binary logistic regression, to provide a robust and precise analysis of the relationship. Infant mortality is a binary outcome (occurs or does not occur), making binary logistic regression an appropriate choice. This method is well-suited for analysing the relationship between a binary dependent variable (infant mortality) and independent variables (i.e. malaria prevalence, cost of treatment, etc.).

Therefore, a study that delves into the relationship between the prevalence of malaria and infant mortality in selected Local Government Areas of Kogi State, utilising a binary logistic regression estimation technique, would not only fill the existing gap in the literature but also contribute significantly to the understanding of the specific dynamics of malaria in this region. This study could inform targeted interventions and policies to mitigate the impact of malaria and improve public health outcomes in Kogi State.

Methodology

Research design
The research design employed for this study is a descriptive and cross-sectional survey research design, focusing on a quantitative approach. The objective is to investigate the impact of the prevalence of malaria on infant mortality in selected Local Government Areas of Kogi State. The study utilised a randomly selected population for data collection and analysis.

Type and sources of data
Data collected for this study was primary data, and they were collected from respondents across seven local government areas of Kogi state, which include Lokoja, Ajaokuta, Omala, Igalamela-Odolu, Kabba/Bunu, Ibaji and Bassa LGAs. Primary data were obtained by way of a structured questionnaire to gather information from the respondents on demographic characteristics, knowledge about factors related to the prevalence of malaria and infant mortality, as well as the influence of malaria prevalence on the productivity of workers.

Population of the study
The population for this study consists of members of households drawn from 21 villages selected from seven LGAs. The LGAs covered in the study include; Lokoja, Ajaokuta, Omala, Igalamela-Odolu, Kabba/Bunu, Ibaji and Bassa. The selected 7 LGAs represent all 3 senatorial districts in Kogi State, with Lokoja and Ajaokuta LGAs from the Central senatorial district, Omala, Igalamela-Odolu, Ibaji, and Bassa LGAs from the East senatorial district, and Kabba/Bunu LGA from the West senatorial district. This selection ensures that the study adequately captures the diverse population across Kogi State. The population of these LGAs based on the National Population Commission Census of 2006 were 196,643; 122,432; 107,968; 147,048; 144,579; 127,572 and 139,687 respectively which equals 985,929 (NPC, 2006). The seven LGAs were selected because the life cycle of mosquito vectors is supported by the climate of the areas and the continuity of malaria transmission is aided by the rainfall of Kogi State. Besides, the seven LGAs purposively selected for investigation had rivers around them and were prone to flooding. The total population of the selected LGAs of the state is 985,929.

The respondents were adults aged 18 years or above, from the selected households in the 21 villages. Only one respondent, preferably the head of household or an adult representative, was interviewed per household. The inclusion criteria of the study involved respondents who were residents of the selected 21 villages from the 7 LGAs, were aged 18 years or above, and gave informed consent to participate. The study excluded respondents who were not permanent residents of the selected villages, were below 18 years of age, and were unable to give informed consent due to cognitive impairment or other reasons.

Sample size of the study

The sample size was calculated by using Yamane's (1967) formula given as:

$$n = \frac{N}{1 + Ne^2}$$

Where: *n* represents sample size; *N* represents Population size; and *e* represents the error of 5 percent. Using this formula, the population size for this study is:

$$n = \frac{985{,}929}{1 + 985{,}929(0.05)^2}$$

$$= \frac{985{,}929}{1 + 985{,}929\ (0.0025)} \quad = \frac{985{,}929}{1+2{,}464.8225} \quad = \frac{985{,}929}{2{,}465.8225} \quad = 399.855 \qquad (2)$$

n = 400.

Sampling techniques

The sample size of the selected 7 LGAs in Kogi State was estimated using Bowley's proportional allocation statistical techniques. Bowley's proportional allocation sampling, which is a type of stratified sampling technique is used when the population is heterogeneous and can be divided into different strata or categories based on certain characteristics. The main justification for using this sampling technique is to ensure that each stratum or category is adequately represented in the sample, proportional to its size in the overall population, making it a suitable choice for conducting a survey or study involving households in Kogi State. The formula is given as follows: $nh = \frac{nNh}{N}$. Where: *nh* is the number of units allocated to each category of the selected LGAs; *Nh* is the number of households in each selected LGA; *n* is the total sample size; and *N* is the actual or total population.

Proportional allocation for the selected 7 LGAs in Kogi State

Lokoja Proportion of respondents to be sampled: $nh = \frac{400 \times 196{,}643}{985{,}929} = 80$; Ajaokuta proportion of respondents to be sampled: $nh = \frac{400 \times 122{,}432}{985{,}929} = 50$; Omala proportion of respondents to be sampled: $nh = \frac{400 \times 107{,}968}{985{,}929} = 43$; Igalamela-Odolu proportion of respondents to be sampled: $nh = \frac{400 \times 147{,}048}{985{,}929} = 60$; Kabba/Bunu proportion of respondents to be sampled: $nh = \frac{400 \times 144{,}579}{985{,}929} = 58$; Ibaji proportion of respondents to be sampled: $nh = \frac{400 \times 127{,}572}{985{,}929} = 52$; Bassa proportion of respondents to be sampled: $nh = \frac{400 \times 139{,}687}{985{,}929} = 57$. Therefore: 80 + 50 + 43 + 60 + 58 + 52 + 57 = 400.

Definition and coding of variables

Two categories of variables will be used in the analysis of the prevalence of malaria and infant mortality rate in Kogi State, which are the dependent and independent variables. The dependent variables are factors that contribute to the infant mortality rate. The independent variables are categorised into socioeconomic status factors and factors that contribute to the prevalence of malaria. The definition and coding of the dependent and independent variables are presented in Table 1 and Table 2 below:

Table 1: Definition and Coding of Dependent Variables

Variable	Description	Coding
Infant Mortality Rate	How would you describe the infant mortality rate in your community?	Low = 1 High = 2

Source: Authors' compilation 2024.

Table 2: Definition and Coding of Independent Variables

Variable	Description	Coding
Prevalence of Malaria	Did you suffer from malaria within the past 6 months?	Yes = 1 No = 2
Transportation Cost	What is the cost of going to the hospital?	< ₦10,000 = 1 ₦10,000 - ₦30,000 = 2 > ₦30,000 = 3
Treatment Cost	What is the cost of treating malaria?	< ₦10,000 = 1 ₦10,000 - ₦30,000 = 2 > ₦30,000 = 3
Prevention Cost	What is the cost of protection from malaria?	< ₦10,000 = 1 ₦10,000 - ₦30,000 = 2 > ₦30,000 = 3

Source: Authors' compilation, 2024.

Methods of data analysis

The Binary Logistic regression method was used to determine the relationships between the prevalence of malaria and infant mortality in selected Local Government Areas of Kogi State. Binary logistic regression is a suitable statistical method when the dependent variable is binary or dichotomous, meaning it has only two possible outcomes. In this case, the study aims to examine the relationship between the prevalence of malaria and the infant mortality rate in selected Local Government Areas of Kogi State. The outcome variable, which is likely to be the presence or absence of infant mortality, is binary, making binary logistic regression an appropriate choice. Descriptive statistics such as percentages, frequencies, cross tabulation and graphs were used to show the socio-demographic characteristics of residents in the selected Local Government Areas of Kogi State.

Model specification

In the revised model from Equation (3) as shown below:

$$H = f\,(I, G, E) \tag{3}$$

Where H is health, I is investments in health, G is genetic endowments, and E is environmental factors.; Infant mortality serves as the dependent variable, while the independent variables include malaria prevalence, cost of treatment, transportation cost, and prevention cost. Binary Logistic Regression is employed to achieve the study's objectives.

Binary Logistic Regression is a statistical method used for analysing the relationship between a binary dependent variable and one or more independent variables (Harrell, 2001). It is primarily used when the dependent variable is categorical and has only two possible outcomes, such as "yes" or "no", "1" or "0", "success" or "failure", etc.

The model is expressed as in Equation (4):

$$P(Y = 1) = \frac{1}{1+e^{(b_0 + b_1X_1 + b_2X_2 + \cdots + b_nX_n)}} \tag{4}$$

Where: $P(Y = 1)$ is the probability that the dependent variable Y equals 1; e is the base of the natural logarithm; b_0 is the intercept; b_1, b_2, ..., b_n are the coefficients for the independent variables X_1, X_2,..., X_n.

Therefore, to achieve the objective of the study which is to investigate the impact of the prevalence of malaria on infant mortality in selected Local Government Areas of Kogi State, the binary logistic regression form of the model is presented in Equation (5) as;

$$P(INM = 1) = \frac{1}{1+e^{(\beta_0 + \beta_1MAL + \beta_2TMC + \beta_3TAC + \beta_4PEC + e)}} \tag{5}$$

Where: *P* (*INM* = 1) is the presence of Infant Mortality; *MAL* is the Prevalence of Malaria; *TAC* is Transportation Cost; *TMC* is Treatment Cost; *PEC* is Prevention Cost; β_0, β_1, β_2, β_3, β_4 are the coefficients for the independent variables, and *e* is the error term.

Validation of instrument
The researchers validated the study instruments (e.g. questionnaires) through two methods: face validity and content validity. For face validity, we examined the instruments to confirm the questions were relevant, clear, and reasonable for the intended audience. For content validity, we analysed whether the instrument questions comprehensively covered and represented all aspects of the outcome variables being measured. This involved ensuring each question mapped directly to an individual outcome variable of interest to provide complete measurement without omitting any key constructs.

Reliability of instrument
To ensure reliability, several measures were taken with the survey instruments (e.g. questionnaires) used in this study. The same questionnaires were administered consistently across all participants to maintain standardisation. The sample size was carefully selected to be representative of the entire target population of adults aged 18 and above from households in the selected 21 villages across the 7 LGAs. Only one respondent, preferably the head of household or an adult representative, was interviewed per household. The survey instruments underwent a rigorous validation process by a team of subject matter experts to verify their relevance and alignment with the research objectives. Trained professionals administered the surveys, underscoring the importance of accuracy and consistency in data collection. Anonymity was maintained to encourage honest responses from participants.

Before final implementation, the instruments were pilot-tested with a sample of 80 respondents to assess their accuracy and identify any potential issues. Reliability analysis was conducted using Cronbach's alpha, with a widely accepted threshold of 0.70 as recommended by Nunnally (1978). However, some scholars like Sekaran (1992) and Slater (1995) have proposed a minimum value of 0.60 as acceptable for hypothesis testing. The survey administration followed a uniform approach across the study population. Experienced researchers analysed the survey results, ensuring accurate interpretation of the findings.

Results and Discussion of Findings
From the course of the field survey, four hundred (400) questionnaires based on the sample size were distributed to respondents of households in 7 LGAs in Kogi State, out of which only three hundred and ninety-seven (397) questionnaires were filled and returned representing 81 per cent references. Figure 1 shows the distribution and return of questionnaires by LGAs

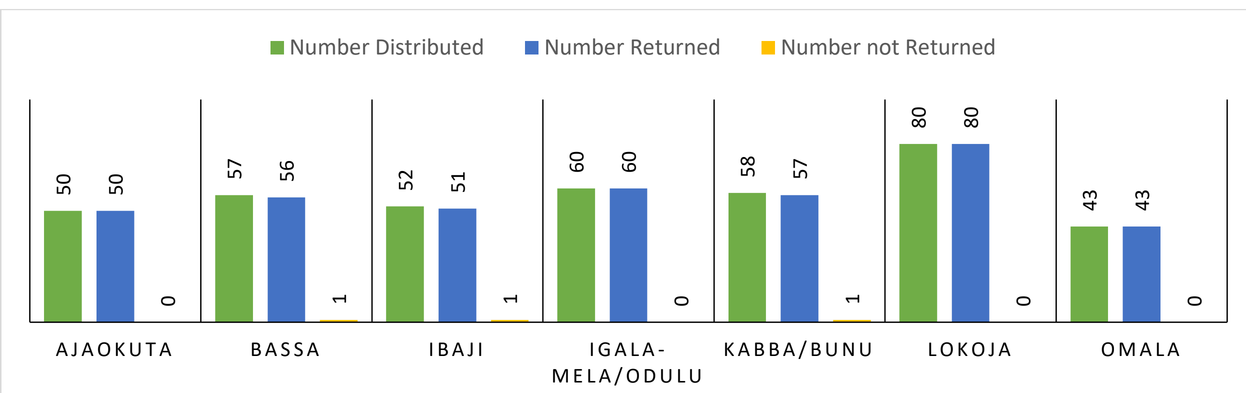

Figure 1: Distribution and Return of Questionnaire
Source: Authors' Field Survey, 2024.

Figure 1 shows that Bowley's proportional allocation statistical technique was employed for the study, resulting in the distribution of 50, 57, 52, 60, 58, 80, and 43 questionnaires to the selected LGAs in Kogi State respectively. This distribution added up to a total of 400 questionnaires. Out of the entire distribution, just 3 copies of the questionnaire remained unreturned, with one originating from each of the following areas: Bassa, Ibaji, and Kabba/Bunu LGAs. This resulted in having 397 copies of questionnaires returned for the study.

Socio-demographic information
To document the appropriateness of the study's respondents, the questionnaires were used to analyse and present the socio-demographic characteristics of the respondents in Figure 2 as outlined below.

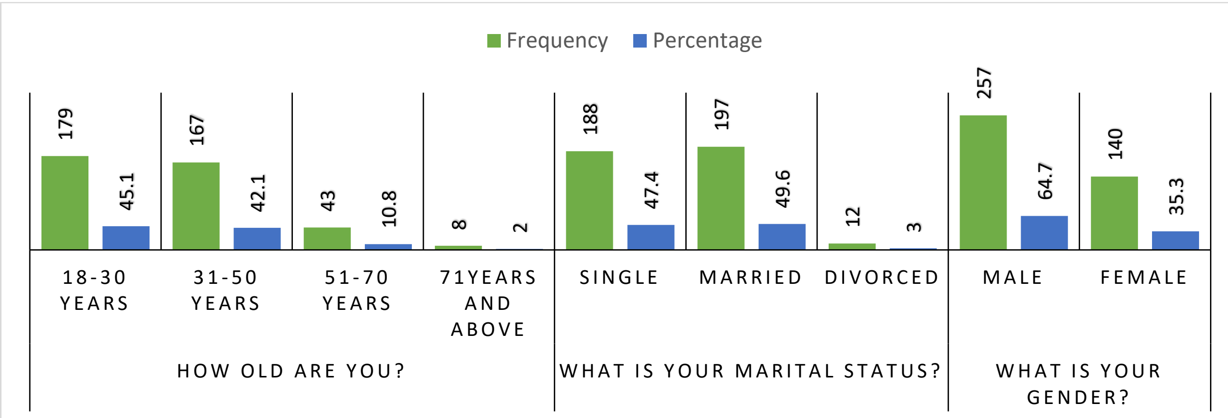

Figure 2: Socio-Demographic Information of Respondents
Source: SPSS Output, 2024.

Figure 2 shows that out of the 397 respondents, 179(45.1%) of them were between the ages of 18–30 years old; 167(42.1%) of the respondents were between the ages of 31–50 years old; 43(10.8%) of the respondents were between the ages of 51–70 years old; while 8(2%) of the respondents were between the ages of 71 years old and above. Therefore, this implies that the majority of the respondents ranged from 18–30 years of age.

Additionally, Figure 2 illustrates that out of the respondents, 188 (47.4%) are single, 197 (49.6%) are married, and 12 (3%) are divorced. Thus, the data indicates that the majority of respondents are married. Lastly, the result from Figure 2 shows that 257(64.7%) of the respondents were males, while 140(35.3%) were females. Therefore, this implies that the majority of the respondents were male in the 7 LGAs of Kogi State.

Information on treatment cost of malaria
The distribution of respondents based on their treatment cost of malaria in the selected Local Government Areas in Kogi State is presented in Figure 3.

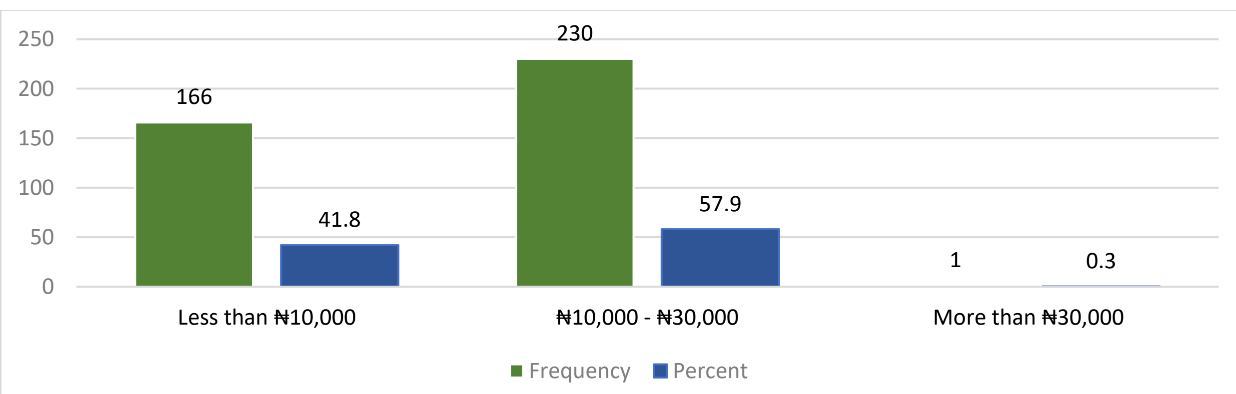

Figure 3: Treatment cost of Malaria of respondents
Source: Authors' computation 2024.

In Figure 3, it is evident that of the 397 respondents, the majority of respondents in the selected Local Government Areas of Kogi State spend within the range of ₦10,000 - ₦30,000 to treat malaria, accounting for 57.9 per cent (230 individuals). Additionally, 41.8 per cent (166 individuals) of respondents spend less than

₦10,000 in treating malaria, and 0.3 per cent (1 individual) of the respondents spend above ₦30,000 in treating malaria.

Information on transportation cost of Malaria
The distribution of respondents based on their transportation cost of going to the hospital to treat malaria in the selected Local Government Areas in Kogi State is presented in Figure 4.

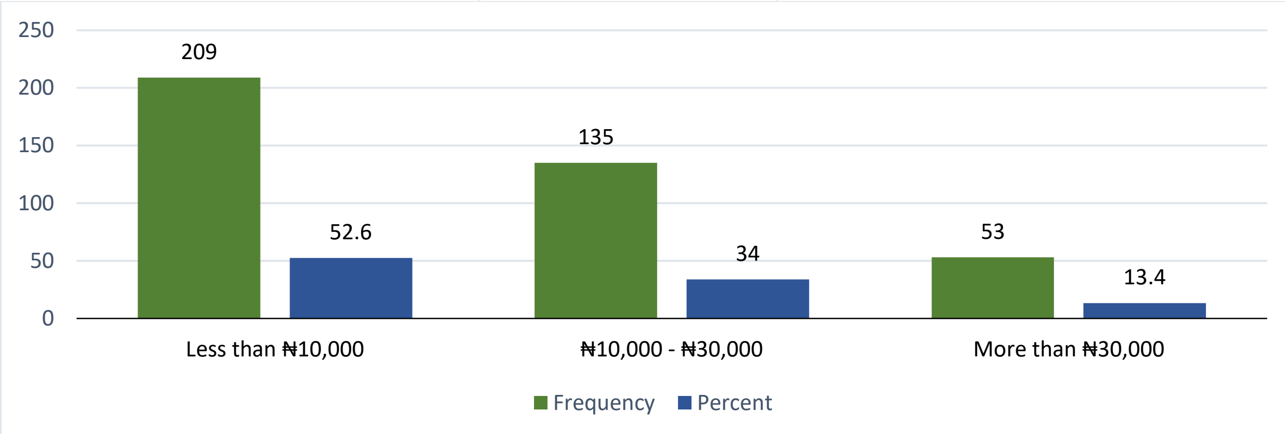

Figure 4: Transportation Cost of Malaria of Respondents
Source: Authors' computation 2024.

In Figure 4, it is evident that of the 397 respondents, the majority of respondents in the selected Local Government Areas of Kogi State spend within the range of less than ₦10,000 to transport themselves to the hospital to treat malaria, accounting for 52.6 per cent (209 individuals). Additionally, 34 per cent (135 individuals) of respondents spend less between ₦10,000 to ₦30,000 in transporting themselves to the hospital to treat malaria, and 13.4 per cent (53 individuals) of the respondents spend above ₦30,000 in transporting themselves to the hospital to treat malaria.

Information on prevention cost of Malaria
The distribution of respondents based on their prevention cost of malaria in the selected Local Government Areas in Kogi State is presented in Figure 5.

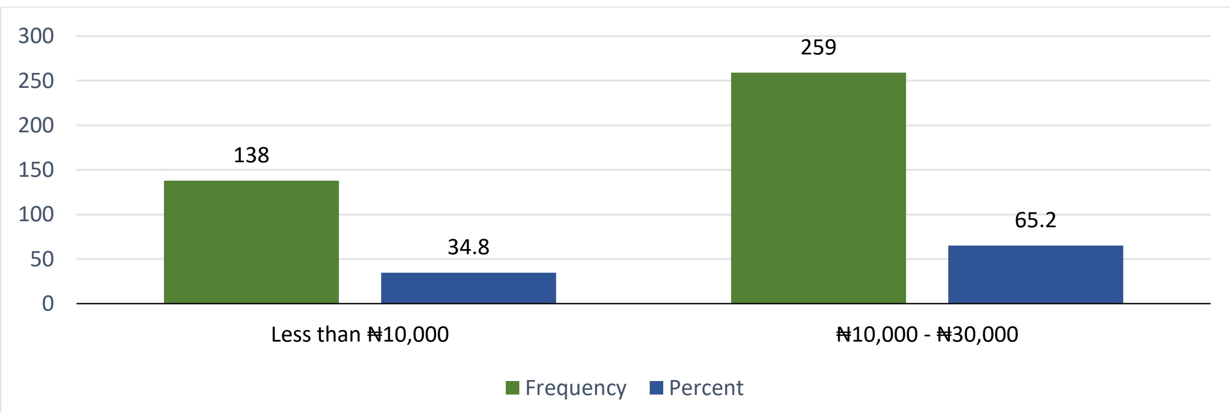

Figure 5: Prevention Cost of Malaria of Respondents
Source: Authors' Computation 2024.

In Figure 5, it is evident that of the 397 respondents, the majority of respondents in the selected Local Government Areas of Kogi State spend within the range of ₦10,000 - ₦30,000 to prevent themselves from malaria infection, accounting for 65.2 per cent (259 individuals). Additionally, 34.8 per cent (135 individuals) of respondents spend less than ₦10,000 to prevent themselves from malaria infection.

Information on mode of Malaria prevention

The distribution of respondents based on their mode of malaria prevention in the selected Local Government Areas in Kogi State is presented in Figure 6.

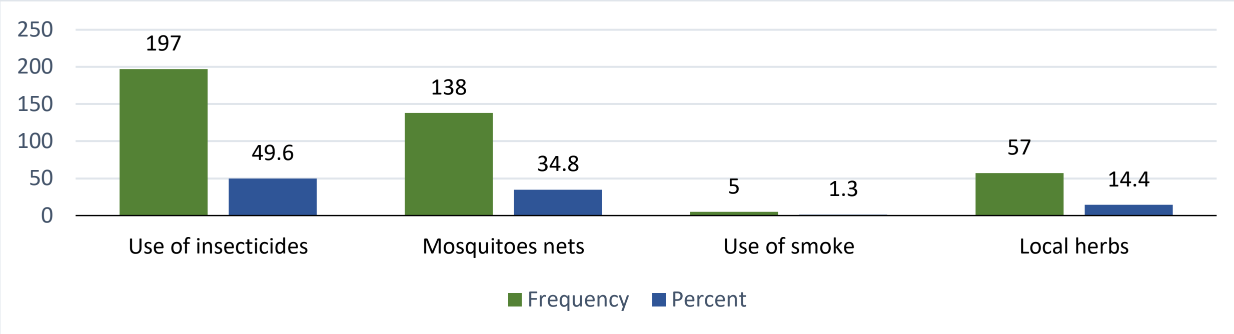

Figure 6: Mode of Malaria Prevention of Respondents
Source: Authors' compilation 2024.

In Figure 6, it is evident that of the 397 respondents, the majority of respondents in the selected Local Government Areas of Kogi State adopt the use of insecticides as their mode of malaria prevention, accounting for 49.6 per cent (197 individuals). Additionally, 34.8 per cent (138 individuals) of respondents adopt the use of mosquito nets as their mode of malaria prevention; 1.3 per cent (5 individuals) of respondents adopt the use of smoke as their mode of malaria prevention; while 14.4 per cent (57 individuals) of respondents adopt the use of local herbs as their mode of malaria prevention.

Binary logistic regression

Binary Logistic Regression was employed to estimate the impact of malaria prevalence on the infant mortality rate in Kogi State. The result of this regression is presented in Table 3 below:

Table 3: Binary Logistic Regression Result of the Impact Prevalence of Malaria on Infant Mortality Rate

Dependent Variable	Independent Variables	Coefficient	Standard Error	Significance
INM	MAL	0.354	0.255	0.165*
	TMC	0.061	0.230	0.792*
	TAC	0.136	0.209	0.514*
	PEC	0.485	0.270	0.072*
	Constant	0.026	0.671	0.969*
Cox of Snell R^2	0.368			
Nagel Kerke R^2	0.532			

** indicates a significance level of $p<0.05$
Source: Authors' Computation (2024)

The result in Table 3 reveals that the coefficient for the prevalence of malaria (MAL) is approximately 0.354, which means that for a unit increase in the prevalence of malaria (MAL), the log-odds of the dependent variable, infant mortality (INM) increase by about 0.354 units. The coefficient for transportation cost (TMC) is approximately 0.061, which implies that for a one-unit increase in transportation cost TMC, the log odds of infant mortality (INM) increase by about 0.061 units. The coefficient for treatment cost (TAC) is approximately 0.136, which indicates that for a one-unit increase in the treatment cost for malaria (TAC), the log odds of infant mortality (INM) increase by about 0.136 units. The coefficient for prevention cost (PEC) is approximately 0.485, which indicates that for a one-unit increase in PEC, the log odds of infant mortality (INM) increase by about 0.485 units.

In addition, the p-values for the coefficients of the prevalence of malaria (MAL), transportation cost of going to the hospital (TMC), treatment cost for malaria (TAC) and prevention cost (PEC) given as 0.165, 0.792, 0.514 and 0.072 respectively are greater than 0.05. This implies that the null hypotheses of all the independent variables are accepted while, the alternative hypotheses are rejected as the prevalence of malaria, transportation cost, treatment cost, and prevention cost are all statistically insignificant. This means that the prevalence of malaria (MAL), transportation cost of going to the hospital (TMC), treatment cost for malaria (TAC) and prevention cost for malaria (PEC) all have a positive, but insignificant impact on infant mortality in the selected Local Government Areas of Kogi State.

Lastly, Nagel Kerke R^2 which is a stronger measure of goodness of fit with a value of 0.532, suggests that the model explains a significant portion of the variance in the dependent variable.

Reliability test result
To ascertain the reliability of the instruments, Cronbach's alpha was employed as shown in Table 4.

Table 4: Reliability Test Result

Valid Number of Respondent	80
Number of Items	5
Cronbach's Alpha	0.746

Source: Authors' Computation (2024)

The reliability test result with a Cronbach's Alpha of 0.746 and no excluded respondents indicates that the survey or questionnaire is highly reliable and that the 5 items used to measure the variables have strong internal consistency. This suggests that the survey is a valid and dependable tool for measuring the variables used in assessing the impact of the prevalence of malaria on infant mortality in selected local government areas of Kogi State.

Discussion of results
The study found that malaria remains a significant public health issue in the selected local government areas of Kogi State, Nigeria. The majority of respondents, who were adults representing their respective households, incurred substantial costs for malaria treatment and prevention, with most spending between ₦10,000 - ₦30,000 for treatment and prevention measures like insecticides and mosquito nets. However, transportation costs to access malaria treatment at hospitals were relatively lower for most respondents.

Despite the prevalence of malaria and associated costs, the binary logistic regression analysis surprisingly revealed that the impact of malaria prevalence, treatment costs, transportation costs, and prevention costs on the infant mortality rate was positive but statistically insignificant. This suggests that while reducing the malaria burden is crucial, other factors may play a more significant role in influencing infant mortality in the region. This outcome goes in conformity with the study of Hauwa (2021) that malaria incidence has a positive impact on the under-five mortality rate. It also revealed that malaria control efforts had a positive effect in reducing malaria prevalence in Nigeria.

The study highlighted the demographic profile of respondents, with a higher representation of younger adults, married individuals, and males. The high response rate of 81 per cent and strong reliability of the survey instrument (Cronbach's alpha of 0.746) lend credibility to the findings. However, further research may be needed to explore the complex interplay of socioeconomic, environmental, and healthcare access factors influencing infant mortality in Kogi State.

Overall, the study provides valuable insights into the malaria landscape and associated costs in selected areas of Kogi State, while also emphasising the need for a comprehensive approach to address the multifaceted determinants of infant mortality in the region.

Conclusion and Recommendations

Conclusion
The study shed light on the complex interplay between malaria prevalence and infant mortality in selected Local Government Areas in Kogi State, Nigeria. While statistically insignificant, the positive relationship between malaria and infant mortality highlights the urgency of addressing this public health challenge. The significant financial and economic burden associated with malaria treatment, transportation, and prevention disproportionately affects vulnerable populations, creating a vicious cycle of poverty and poor health outcomes.

This study provides a foundation for evidence-based policymaking, emphasising the need for a comprehensive approach to public health challenges in Kogi State.

Policy recommendations
Based on the findings of the study, the following policy recommendations were proffered:

Despite the economic investments in malaria treatment and prevention, the study suggests that economic factors may not be the sole determinants of infant mortality. The government should enhance healthcare accessibility in urban and rural areas by investing in medical facilities, personnel, and transportation infrastructure, ensuring timely and efficient healthcare delivery.

Given the positive impact of the incidence of malaria on infant mortality in Kogi State, the government should aid in reducing infant mortality by focusing on comprehensive education programs targeting communities and emphasising malaria prevention measures. This includes promoting awareness about the use of insecticides, mosquito nets, and other preventive measures. This can also be achieved by encouraging the use of community health workers to distribute mosquito nets, educate residents on preventive measures, and conduct regular health check-ups, fostering a sense of ownership and responsibility within communities.

Acknowledging the economic burden associated with malaria treatment, the government should consider implementing targeted subsidies for antimalarial medications. This can alleviate financial strain on families and encourage prompt and adequate treatment, reducing the severity and duration of malaria infections.

Considering the World Health Organisation's recommendation that health facilities should be located within a 5km radius of communities, the study's finding on significant transportation costs associated with seeking healthcare highlights the need for strategic placement of medical facilities in Kogi State. This could involve establishing new hospitals or strengthening existing ones in underserved areas, ensuring that they are within the recommended 5km radius of residential areas.

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APPENDIX

SECTION A

Identification and Socio-Demographic Information

Instructions: Please fill in the line space and tick the box [√] where appropriate.

1. Name of individual household member: (Optional) ……………………………………………
2. Local Government Area: ……………………………………………………………………
3. Village: ……………………………………………………………………………………...
4. How old are you? (a) 18-30 years [ ] (b) 31-50 years [ ] (c) 51-70 years [ ] (d) 71years and above [ ]
5. What is your marital status? (a) Single [ ] (b) Married [ ] (c) Divorced [ ]
6. What is your gender? (a) Male [ ] (b) Female [ ]

SECTION B

Prevalence of Malaria

Instructions: Please tick the box [√] where appropriate.

7. Did you suffer from malaria within the past 6 months? (a) Yes [ ] (b) No [ ]
8. How many times did you suffer from malaria during the last 6 months? (a) Once [ ] (b) Twice [ ] (c) Thrice [ ] (d) Four times [ ] (e) Five times [ ] (f) Six times [ ]
9. How many days did a member of your household suffer from malaria in a year? (a) One day [ ] (b) Two days [ ] (c) Three days [ ] (d) Four days [ ] (e) Five days [ ] (f) Six days [ ]

SECTION C

Treatment Cost of Malaria

Instructions: Please tick the box [√] where appropriate.

10. What is the cost of treating malaria? (a) Less than ₦10,000 [ ] (b) ₦10,000 - ₦30,000 [ ] (c) More than ₦30,000 [ ]

SECTION D

Transportation Cost of Malaria

Instructions: Please tick the box [√] where appropriate.

11. What is the cost of going to hospital? (a) Less than ₦10,000 [ ] (b) ₦10,000 - ₦30,000 [ ] (c) More than ₦30,000 [ ]

SECTION E

Prevention Cost of Malaria

Instructions: Please tick the box [√] where appropriate.

12. How do you protect yourself and your household from malaria? (a) Use of insecticides [ ] (b) Mosquitoes nets [ ] (c) Use of smoke [ ] (d) Local herbs [ ]
13. What is the cost of protection from malaria? (a) Less than ₦10,000 [ ] (b) ₦10,000 - ₦30,000 [ ] (c) More than ₦30,000 [ ]

SECTION F

Infant Mortality

Instructions: Please tick the box [√] where appropriate.

14. Do you have a child/infant in your household? (a) Yes [ ] (b) No [ ]
15. Are you aware of infant mortality rate in your community? (a) Yes [ ] (b) No [ ]
16. How would you describe the infant mortality rate in your community? (a) Low [ ] (b) Average [ ] (c) High [ ]
17. What are the factors that contribute to infant mortality in your community? (a) Environmental factors [ ] (b) Biological factors [ ] (c) Human-related factors [ ]
18. Do you find it easy for infants in your household to access healthcare services when needed? (a) Yes [ ] (b) No [ ]