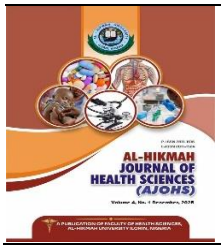
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Original Article

Impact Assessment of Climate Change on the Spread of Malaria Diseases among Residents of Selected Communities in Ilorin West LGA, Ilorin, Kwara State, Nigeria

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ABSTRACT

Introduction: Malaria remains a persistent public health problem, especially in tropical and subtropical countries. This study assessed the impact of climate change on the spread of malaria diseases among residents of selected communities in Ilorin West Local Government Area (LGA), Kwara State, Nigeria

Method: A descriptive cross-sectional design was adopted, with data collected from 427 adult residents selected through multistage sampling using a structured questionnaire. Data were analysed using descriptive statistics, while chi-square goodness-of-fit tests were used to test the hypotheses at 0.05 alpha level. Ethical approval was obtained from the Kwara State Ministry of Health Research Ethics Committee.

Results: Findings revealed that climate change-induced malaria is highly prevalent in Ilorin West LGA (grand mean = 0.73), a significant positive relationship exists between climate change and malaria transmission (grand mean = 3.22), and current malaria control strategies are only moderately effective (grand mean = 2.96). All three hypotheses tested were statistically significant ($p < .001$).

Conclusion: The study concludes that climate change is a major driver of malaria transmission in Ilorin West LGA, and existing control measures remain insufficient to address the compounded burden. It is recommended that climate data be integrated into malaria surveillance, and that drainage infrastructure and healthcare facility capacity be strengthened.

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Introduction

Malaria remains a persistent public health problem, especially in tropical and subtropical countries. In 2022, 249 million people were estimated to have suffered malaria, and 608,000 people died, with more than 95% of these cases occurring in sub-Saharan Africa (World Health Organization, 2023). Nigeria carries about 27% of the global malaria burden, and malaria is responsible for approximately 60% of outpatient visits and 30% of hospital admissions, especially among children under five years and pregnant women (Federal Ministry of Health, 2021). Malaria transmission is closely associated with environment and climate. The intrinsic incubation

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period of Plasmodium parasites and the extrinsic incubation period of Anopheles mosquitoes are directly affected by temperature, rainfall, and humidity, with warmer temperatures speeding up parasite development, and stagnant water bodies resulting from rainfall providing ideal breeding grounds for Anopheles mosquitoes (Paaijmans et al., 2010). These dynamics have been exacerbated by long-term changes in temperature, precipitation, and extreme weather events, referred to as climate change. According to the Intergovernmental Panel on Climate Change (2022), Africa is experiencing increases in temperature, rainfall, wet-season duration, and flooding frequency, which are likely to expand the geographic distribution and seasonality of vector-borne diseases such as malaria.

In Nigeria, climate change has manifested as erratic rainfall, extended wet seasons, rising temperatures, and increased flooding in the Middle Belt and northern parts of the country, creating more breeding opportunities for mosquitoes, increasing mosquito density, and extending malaria transmission seasons (Nigerian Meteorological Agency, 2022). Kwara State in North-Central Nigeria has a tropical savanna climate with high daily temperatures and seasonal precipitation, with recent trends of increased rainfall resulting in urban flooding, compounded by poor drainage conditions, particularly in urban and peri-urban areas such as Ilorin West LGA.

Malaria control programmes, including Insecticide Treated Nets (ITNs), Indoor Residual Spraying (IRS), Rapid Diagnostic Testing, and Artemisinin-based Combination Therapy (ACT), are widely deployed, yet malaria remains endemic in Ilorin West LGA. Nigeria places comparatively limited emphasis on climate-sensitive malaria control interventions relative to biomedical interventions, and there is little evidence on the localised effect of climate variables on malaria trends. It was on this premise that this study examined the prevalence of climate change-induced malaria, the relationship between climate change and malaria transmission, and the effectiveness of existing malaria control measures in Ilorin West LGA.

Although malaria has been reasonably well controlled in Nigeria over the last two decades, the disease still poses a serious public health burden, with vulnerable groups, including children under five years, pregnant women, and low-income families, continuing to suffer high morbidity and mortality (Federal Ministry of Health, 2021). Malaria outbreaks continue to occur repeatedly in Ilorin West LGA, mainly due to environmental and infrastructural problems, including poor drainage systems, stagnant water bodies, poor housing conditions, and inadequate waste management, compounded by climate change-driven flooding and extended rainy seasons. Changes in rainfall, humidity, and average temperature have created favourable breeding and development conditions for mosquito populations and parasites; however, there is limited empirical evidence linking these climatic changes to malaria transmission trends at the local government level, as most Nigerian studies on climate change and malaria are conducted at national or regional levels. This gap constrains effective public health planning and malaria control at the local level in the absence of localised, climate-specific malaria data.

This study therefore assessed the impact of climate change on the spread of malaria disease among residents of selected communities in Ilorin West Local Government Area, Kwara State, Nigeria, with the following specific objectives: to determine the prevalence of climate change-induced malaria in Ilorin West LGA; to investigate the relationship between climate change and malaria transmission in Ilorin West LGA; and to evaluate the effectiveness of current malaria control strategies in addressing climate-related challenges in Ilorin West LGA.

Research Methodology

Research Design

The study adopted a descriptive cross-sectional design, which enabled the simultaneous collection of data on climatic conditions, environmental factors, and malaria occurrence from the population at a single point in time, allowing for examination of the association between climatic variables and the pattern of malaria transmission.

Population of the Study

The population of the study comprised all adult residents aged 18 years and above resident in Ilorin West Local Government Area, Kwara State, Nigeria.

Sample Size Determination and Sampling Techniques

The sample size was determined using Cochran's formula at the 95% confidence level and 5% margin of error for cross-sectional studies, with a 10% attrition allowance factored in, yielding a final sample of 427 respondents. A multi-stage sampling method was employed, whereby wards were selected via simple random sampling, followed by systematic sampling of households within the selected wards, and then random selection of one eligible adult respondent from each household.

Research Instrument

A structured questionnaire was used to gather data on respondents' demographic characteristics, the relationship between climate and malaria transmission, current malaria control measures and their perceived impact, and current levels of malaria prevalence attributable to climate change.

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Validity of the Instrument
Face and content validity of the instrument were established by a panel of experts, including public health specialists, epidemiologists, and climate researchers, who reviewed the questionnaire for relevance, clarity, and appropriateness of items.

Reliability of the Instrument
A pilot study was conducted in a neighbouring Local Government Area, and the reliability of the instrument was tested using Cronbach's Alpha, which yielded a coefficient of 0.84, confirming that the instrument was reliable.

Data Analysis
The Statistical Package for the Social Sciences (SPSS) version 26.0 was used to code, enter, and clean the data. Means, standard deviations, frequencies, and percentages were used to summarise the characteristics of respondents and answer the research questions, while chi-square goodness-of-fit tests were used to test the postulated hypotheses at 0.05 alpha level.

Ethical Consideration
Ethical approval was obtained from the Kwara State Ministry of Health Research Ethics Committee prior to data collection. All respondents provided verbal informed consent and were informed of the study's aims, procedures, and their right to withdraw at any time. Confidentiality and anonymity were maintained throughout the study, in accordance with international standards for the protection of human subjects (World Health Organization, 2017).

Results
Demographic Characteristics of Respondents
Table 1: Demographic Characteristics of Respondents (N = 427)

Variable	Category	Frequency (%)
Age Group (Years)	18-25	85 (19.9%)
	26-35	132 (30.9%)
	36-45	118 (27.6%)
	46-55	62 (14.5%)
	Above 55	30 (7.0%)
Sex	Male	219 (51.3%)
	Female	208 (48.7%)
Educational Level	No Formal Education	38 (8.9%)
	Primary School	74 (17.3%)
	Secondary School	162 (37.9%)
	Tertiary (OND/HND/Degree)	120 (28.1%)
	Postgraduate	33 (7.7%)
Years of Residence	1-5 years	52 (12.2%)
	6-10 years	98 (22.9%)
	11-20 years	145 (34.0%)
	Above 20 years	132 (30.9%)
Household Monthly Income (₦)	Below 50,000	138 (32.3%)
	50,001-100,000	152 (35.6%)
	100,001-150,000	89 (20.8%)
	Above 150,000	48 (11.2%)

Table 1 shows the demographic characteristics of the 427 respondents. The largest proportion of respondents fell within the 26-35 years age bracket (30.9%), reflecting a predominantly young to middle-aged adult sample, with a near-equal sex distribution (male: 51.3%; female: 48.7%). Most respondents had lived in Ilorin West LGA for 11 years or more (64.9% combined), indicating long-term exposure to local climatic conditions, while 67.9% earned ₦100,000 or below monthly, confirming a predominantly low-income sample with limited capacity to access optimal malaria prevention and treatment resources.

Research Question One: What is the prevalence of climate change-induced malaria in Ilorin West LGA?

Table 2: Descriptive Statistics of Prevalence of Climate Change-Induced Malaria

Item	Yes	No	Mean	SD
Experienced malaria infection in past 12 months	324 (75.9%)	103 (24.1%)	0.76	0.43
Malaria frequency increased in recent years	298 (69.8%)	129 (30.2%)	0.70	0.46

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Malaria attacks increase during/after heavy rainfall	356 (83.4%)	71 (16.6%)	0.83	0.37
Multiple malaria episodes in a single rainy season	271 (63.5%)	156 (36.5%)	0.63	0.48
Aware of hospitalisation for malaria in past year	312 (73.1%)	115 (26.9%)	0.73	0.44
Grand Mean			**0.73**	

Table 2 shows that the grand mean for prevalence of climate change-induced malaria was 0.73, indicating that approximately 73% of respondents gave affirmative responses relating to climate change-induced malaria prevalence. This confirms that malaria induced by climate-related conditions is substantially prevalent and represents an ongoing public health burden in Ilorin West LGA.

Table 3: Chi-Square Goodness-of-Fit Test for Prevalence of Climate Change-Induced Malaria

Item	Yes n (%)	No n (%)	Total	χ^2
Experienced malaria in past 12 months	324 (75.9%)	103 (24.1%)	427	
Malaria frequency increased	298 (69.8%)	129 (30.2%)	427	
Increases during/after rainfall	356 (83.4%)	71 (16.6%)	427	
Multiple episodes in rainy season	271 (63.5%)	156 (36.5%)	427	
Aware of hospitalisation for malaria	312 (73.1%)	115 (26.9%)	427	
Pooled Total	**1,561 (73.1%)**	**574 (26.9%)**	**2,135**	**456.285**

Note. *Expected frequency = 50% Yes / 50% No. $p < .001$. Critical value $\chi^2(1) = 3.841$ at $p = .05$. $df = 1$ for each item and the pooled test.*

HO1: There is no significant prevalence of climate change-induced malaria in Ilorin West LGA.

Table 3 shows that the pooled chi-square value was $\chi^2(1) = 456.285$, which is significantly greater than the critical value of 3.841 at $p < .001$. The null hypothesis (HO1), which stated that there is no significant prevalence of climate change-induced malaria in Ilorin West LGA, was therefore rejected. This implies that there is a statistically significant prevalence of climate change-induced malaria in Ilorin West LGA.

Research Question Two: What is the relationship between climate change and malaria transmission in Ilorin West LGA?

Table 4: Descriptive Statistics of Climate Change and Malaria Transmission

Item	SA	A	D	SD	Mean	SD
Rising temperatures increased mosquito populations	182 (42.6%)	165 (38.6%)	54 (12.6%)	26 (6.1%)	3.14	0.90
Rainfall/flooding create more breeding sites	215 (50.4%)	158 (37.0%)	38 (8.9%)	16 (3.7%)	3.31	0.82
Prolonged rainy season extended transmission period	176 (41.2%)	172 (40.3%)	47 (11.0%)	32 (7.5%)	3.17	0.89
Poor drainage worsened by rainfall promotes breeding	229 (53.6%)	147 (34.4%)	35 (8.2%)	16 (3.7%)	3.35	0.83
Seasonal temperature fluctuations affect outbreak timing	168 (39.3%)	179 (41.9%)	52 (12.2%)	28 (6.6%)	3.12	0.89
Grand Mean					**3.22**	**0.87**

Table 4 shows that the grand mean for the relationship between climate change and malaria transmission was 3.22, indicating general agreement that climate change phenomena, particularly rising temperatures, flooding, prolonged rainy seasons, and drainage failures, are positively associated with malaria transmission in Ilorin West LGA.

Table 5: Chi-Square Goodness-of-Fit Test for the Relationship between Climate Change and Malaria Transmission

Item	Agree n (%)	Disagree n (%)	Total	χ^2
Rising temperatures increased mosquito populations	347 (81.3%)	80 (18.7%)	427	
Rainfall/flooding create more breeding sites	373 (87.4%)	54 (12.6%)	427	

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Prolonged rainy season extended transmission	348 (81.5%)	79 (18.5%)	427	
Poor drainage promotes mosquito breeding	376 (88.1%)	51 (11.9%)	427	
Temperature fluctuations affect outbreak timing	347 (81.3%)	80 (18.7%)	427	
Pooled Total	1,791 (83.9%)	344 (16.1%)	2,135	980.707

Note. *Agree = Strongly Agree + Agree; Disagree = Strongly Disagree + Disagree. Expected frequency = 50% each. $p < .001$. Critical value $\chi^2(1) = 3.841$ at $p = .05$. $df = 1$ for each item and the pooled test.*

HO2: There is no significant relationship between climate change and malaria transmission in Ilorin West LGA.

Table 5 shows that the pooled chi-square statistic was $\chi^2(1) = 980.707$, $p < .001$, with agreement responses (83.9%) clearly and significantly outnumbering disagreement responses (16.1%). The null hypothesis (HO2) was therefore rejected. This implies that there is a statistically significant positive relationship between climate change and malaria transmission in Ilorin West LGA.

Research Question Three: How effective are current malaria control strategies in addressing climate-related challenges in Ilorin West LGA?

Table 6: Descriptive Statistics of Effectiveness of Current Malaria Control Strategies

Item	SA	A	D	SD	Mean	SD
ITNs have been effective in reducing malaria cases	154 (36.1%)	189 (44.3%)	58 (13.6%)	26 (6.1%)	3.07	0.88
IRS programmes helped reduce mosquito populations	132 (30.9%)	171 (40.0%)	79 (18.5%)	45 (10.5%)	2.91	0.96
Health facility services are adequate for climate-driven malaria	98 (22.9%)	152 (35.6%)	112 (26.2%)	65 (15.2%)	2.68	1.00
Environmental sanitation reduced malaria transmission	185 (43.3%)	163 (38.2%)	52 (12.2%)	27 (6.3%)	3.17	0.90
Community campaigns raised climate-malaria awareness	143 (33.5%)	175 (41.0%)	70 (16.4%)	39 (9.1%)	2.98	0.95
Grand Mean					**2.96**	**0.94**

Table 6 shows that the grand mean for effectiveness of current malaria control strategies was 2.96, indicating that current malaria control strategies are perceived as only moderately effective and insufficient to adequately address the additional burden imposed by climate change.

Table 7: Chi-Square Goodness-of-Fit Test for Effectiveness of Current Malaria Control Strategies

Item	Agree n (%)	Disagree n (%)	Total	χ^2
ITN use effective in reducing malaria	343 (80.3%)	84 (19.7%)	427	
IRS programmes helped reduce mosquito populations	303 (71.0%)	124 (29.0%)	427	
Health facility services adequate for climate-driven malaria	250 (58.5%)	177 (41.5%)	427	
Environmental sanitation reduced transmission	348 (81.5%)	79 (18.5%)	427	
Community campaigns raised climate-malaria awareness	318 (74.5%)	109 (25.5%)	427	
Pooled Total	**1,562 (73.1%)**	**573 (26.9%)**	**2,135**	**458.136**

Note. *Agree = Strongly Agree + Agree; Disagree = Strongly Disagree + Disagree. Expected frequency = 50% each. $p < .001$. Critical value $\chi^2(1) = 3.841$ at $p = .05$. $df = 1$ for each item and the pooled test.*

HO3: Current malaria control strategies in addressing climate-related challenges in Ilorin West LGA are not significant.

Table 7 shows that the pooled chi-square statistic was $\chi^2(1) = 458.136$, $p < .001$, indicating that overall agreement regarding the significance of current malaria control strategies (73.1%) was significantly greater than disagreement (26.9%). The null hypothesis (HO3) was therefore rejected. This implies that current malaria control strategies in addressing climate-related challenges in Ilorin West LGA are statistically significant; however, the findings simultaneously indicate that while these strategies are

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statistically recognised as significant, they are only moderately effective in practice.

Discussion

Prevalence of Climate Change-Induced Malaria

The finding that climate change-induced malaria is highly prevalent (grand mean = 0.73) in Ilorin West LGA is comparable to the documented climate-driven transmission pathway in the literature and is consistent with the World Health Organization's (2023) report of 249 million malaria cases and 608,000 deaths globally, with Nigeria accounting for approximately 27% of the fatality burden in 2022. Raimi et al. (2021) similarly attributed climate change-induced environmental degradation as a key driver of the vector-borne disease burden in Nigeria's North-Central region. The present results corroborate those of Nyawanda et al. (2023), who reported in a longitudinal study in western Kenya that increased rainfall was positively and significantly related to malaria incidence after two to four weeks, a pattern reflected by the 83.4% of respondents in this study who reported that malaria attacks increase during or after heavy rainfall. However, Lowe et al. (2021) caution that the relationship between rainfall and malaria is non-linear, as extreme rainfall can temporarily limit transmission by washing away breeding sites before receding and creating stagnant pools that later elevate transmission risk. It should also be noted that the high prevalence of 75.9% for recent malaria infection should be considered alongside the low-income profile of respondents, as Talapko et al. (2019) note that self-reported prevalence may also reflect delayed health-seeking behaviour in addition to actual transmission.

Relationship between Climate Change and Malaria Transmission

The finding of a significant positive relationship between climate change and malaria transmission (grand mean = 3.22) is consistent with the literature. Agreement on the role of temperature is biologically supported by Beck-Johnson et al. (2013), who demonstrated using mathematical modelling that the growth and development of Anopheles vectors and their biting frequency are positively correlated with temperature within the range of 16°C-35°C, a range that covers Ilorin's annual mean temperature, thereby reducing the extrinsic incubation period of Plasmodium parasites. A similar positive relationship between rainfall and malaria cases was observed by Hasyim et al. (2018), and Abiodun et al. (2016) confirmed that rainfall provides the larval habitat on which the population growth of *Anopheles arabiensis* depends. The high mean score for the relationship between poor drainage and worsening flooding (3.35) aligns with Matthew (2020), who reported a high malaria burden in Middle Belt urban areas with inadequate drainage following heavy rainfall. However, this relationship in West Africa is moderated by local factors such as vegetation cover and soil permeability (Diouf et al., 2020) and tends to be unimodal rather than linear, turning around approximately 35°C (Paaijmans et al., 2010), suggesting that the relationship observed in Ilorin West LGA may similarly be moderated by local factors not directly measured in this survey.

Effectiveness of Current Malaria Control Strategies

The finding that health facility adequacy recorded the lowest mean score (2.68) among the control-strategy items aligns with the Federal Ministry of Health's (2021) assessment of underfunding, understaffing, and undersupply of essential malaria commodities in primary healthcare facilities in Nigeria. Ekpono et al. (2019), in a study on the impact of diagnostic-kit and antimalarial-drug stockouts on malaria outcomes, noted that facility-level supply gaps increase the likelihood of poor outcomes and reinforce the perception that the health system is inadequate, a finding reiterated by Egwu, Agu and Nwaneri (2023) in their review of malaria control constraints across sub-Saharan Africa. The moderate perceived effectiveness of ITNs is consistent with evidence that consistent ITN use contributes to a 50-55% reduction in transmission (Fletcher et al., 2020), and that while ITNs remain the most cost-effective prevention tool available, their effectiveness is diminished by inconsistent field use (Lindsay, Thomas & Kleinschmidt, 2021). The comparatively low rating of indoor residual spraying corresponds with the documented emergence of insecticide resistance among Anopheles gambiae in West Africa (Obeagu&Obeagu, 2024), a trend that climate change may further exacerbate through rising temperatures that favour resistance spread. It is important to note that although community perceptions of effectiveness may not always align precisely with clinical outcomes, they should be corroborated with objective entomological data in future evaluations (Ferreira and Castro, 2016).

Conclusion

C limate change-induced malaria is highly prevalent in Ilorin West LGA, and that a statistically significant positive relationship exists between climate change and malaria transmission in the study area, with the key mechanisms identified being rising temperatures, flooding, prolonged rainy seasons, and poor drainage. Although residents statistically recognise the significance of current malaria control efforts, they perceive only limited improvement from these efforts, particularly regarding the quality of primary healthcare facilities and indoor residual spraying.

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Overall, the effects of climate change constitute a significant and growing contributor to malaria transmission in Ilorin West LGA, and current malaria control interventions remain insufficient to meet the compounded burden that climate change creates.

Declaration

We hereby declare that this study is a record of our research work. It has neither been presented nor accepted in any previous application for a higher degree. All sources of information have been specifically acknowledged and no conflict of interest.

Conflict of Interest

None encountered.

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