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Spatial Pattern and Distribution of Malaria Cases in Owo Local Government Area, Nigeria

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ABSTRACT: *This study investigates the spatial pattern and distribution of malaria cases in Owo Local Government Area, Nigeria. A multi-stage sampling technique was used, such that 50% of the 7 urban political wards were selected. The selected 4 urban political wards comprise of 12,466 household heads. Also, 10% of the 127 rural settlements were randomly selected making 14 rural settlements with 9,095 household heads. In all, 1.5% of the total household heads, comprising 187 in the urban areas and 136 in the rural settlements were interviewed using systematic random sampling techniques. A secondary data source obtained from relevant healthcare facilities was used for spatial analysis. Specifically, 59 selected residential settlements were used as the input feature class, while the records on malaria cases in each residential settlement during the reviewed year serve as the input field for the analyses. Spatial statistical functions provided by ArcGIS 10.8 and Geospatial tool are utilized for data analysis. Findings revealed preponderance of malaria within the urban core area of Owo. This can be attributed to inadequate wastewater management, poor waste disposal methods, and inadequate environmental education and awareness. On the other hand, malaria cases in rural areas were relatively low due to the use of alternative disease treatment methods. To ameliorate these challenges, there is a need for improved access to a safe and high-quality environment, implement suitable sanitation facilities and solid waste disposal methods, promote community-based educational initiatives and awareness campaigns, and encouraging hygienic behaviors. Through these, the health challenges of malaria can be mitigated.*

KEYWORDS: spatial pattern, distribution, disease, health, settlement

INTRODUCTION

The health of individuals is influenced by a range of environmental components including ecological and climatic variables, (Jane & Zewotir, 2020). These factors are crucial in molding their sense of self and largely impacting their overall health.

One major anticipation of environmental enhancement in human societies is the acquisition of health benefits (Okunlola & Oyeyemi, 2019). The health of individuals is determined by various environmental elements including ecological and climatic factors, factors related to the healthcare system, practices in land use, and patterns of urbanization (Fayiga *et al,* 2018). These factors play pivotal roles in shaping their sense of self and largely impacting their overall health. Consequently, the presence of humans on planet Earth is plagued by numerous health-related challenges like waterborne diseases caused by the environmental conditions they inhabit (Eneji, *et al,* 2015). Health is a condition characterized by complete state of physical, mental, and social well-being, rather than simply the absence of disease and infirmity (World Health Organisation [WHO], 2018a). Health is a state that arises from the comprehensive functioning of an individual within their environment, empowering them to lead a personally fulfilling and socially beneficial life (Olugbamila, 2016).

Malaria, a life-threatening disease transmitted to humans by certain species of mosquitoes, predominantly occurs in regions with tropical climates. This disease, caused by a parasite, is both preventable and treatable (Mrignendra *et al,* 2024). The most recent World Malaria Report indicates that there were 249 million malaria cases in 2022, a slight increase from the 244 million cases reported in 2021. The number of malaria-related deaths was estimated at 608,000 in 2022, slightly lower than the 610,000 deaths recorded in the previous year (WHO, 2024). The World Health Organization (2024) highlights that the African Region continues to bear a disproportionate burden of malaria globally, with approximately 94% of all malaria cases and 95% of deaths occurring in the region in 2022. Moreover, children under the age of 5 represented around 78% of all malaria fatalities in this region. Notably, four African nations - Nigeria (26.8%), Democratic Republic of the Congo (12.3%), Uganda (5.1%), and Mozambique (4.2%) - collectively accounted for more than half of all malaria-related deaths worldwide.

According to the World Health Organization (WHO) in 2021, malaria represents a major public health issue in Nigeria, experiencing an approximate 68 million instances and 194,000 deaths attributed to the disease during the same year. Nigeria is responsible for 27% of all worldwide malaria occurrences and 31% of global malaria-related deaths, thereby emerging as the primary contributor to the overall malaria burden globally (WHO, 2021). Recognizing the pivotal role of robust healthcare in the advancement of a nation, and notwithstanding the advancements achieved in the direction of malaria eradication, the disease persists as a notable public health challenge within Nigeria (Chilochibi *et al,* 2024) and specifically within Ondo State. Consequently, the fundamental objective of this investigation is to examine the spatial pattern and distribution of malaria cases within the Owo Local Government Area of Ondo State.

LITERATURE REVIEW

Concept of Disease Causation

As Dharmashree *et al* (2020) stated, the concept of disease is often perceived as the opposite of health, representing a deviation from the normal physiological function. Disease is defined by

Webster as "a state in which bodily health is compromised, a departure from a condition of well-being, and a modification of the human body that disrupts the execution of essential functions." Nevertheless, from the ecological view, disease is characterized as "an inadequate adjustment of the human organism to its surroundings" (Pearce *et al*, 2020).

The Epidemiological triad revealed that disease arises due to an imbalance in the interactions among three fundamental components: Host, Agent, and Environment. Disease occurs when a susceptible host encounters the pathogenic agent within a compatible environment (Anders, 2020). This perspective encompasses a broader framework and transcends the constraints of the germ theory. Disrupting any of these three components offers a strategy to interrupt the disease progression, hence highlighting areas where preventive measures should be directed.

Spatial Analysis in Epidemiology

Over the past two decades, there has been a significant increase in the utilization of spatial analysis within the domain of epidemiological surveillance and research, exhibiting an exponential trend. The use of geographic information system (GIS) technologies has the potential to contribute to the comprehension of the dynamics of disease incidence and distribution. Consequently, this can aid in the identification of high-risk areas or locations (Ahmad *et al*, 2017). Thus, the implementation of geographic information technologies can effectively support the provision of health surveillance services (Joseph *et al*, 2018). Paez *et al* (2021), assert that spatial epidemiology, a subfield of epidemiology, is dedicated to the exploration of spatial patterns in health outcomes, showcasing a close connection to health geography. More specifically, spatial epidemiology concerns itself with the characterization and analysis of disease and its geographic disparities. Using geographic information systems and spatial analysis technology, spatial epidemiology aims to delineate and scrutinize human diseases, encompassing the spatial distribution characteristics of health and hygiene occurrences, as well as the regularity of alterations and advancements.

Furthermore, spatial epidemiology delves into the decisive factors that can exert influence on public health and furnishes strategies and measures for disease prevention, treatment, and the provision of health promotion and hygiene services (Talisuna *et al*, 2020). In Li and Wang's study (2013), it was documented that disease mapping represents the most pivotal instrument in spatial epidemiology, serving to illustrate and assess the geographical dissemination of diseases. However, there is an escalating recognition of the peril that epidemics, disasters, and public health emergencies pose to global health security and individuals' livelihoods, surpassing their impact solely on human health. As evidenced in Figure 1, each one of the 47 countries within the WHO African Region confronts health security threats (WHO, 2018b).

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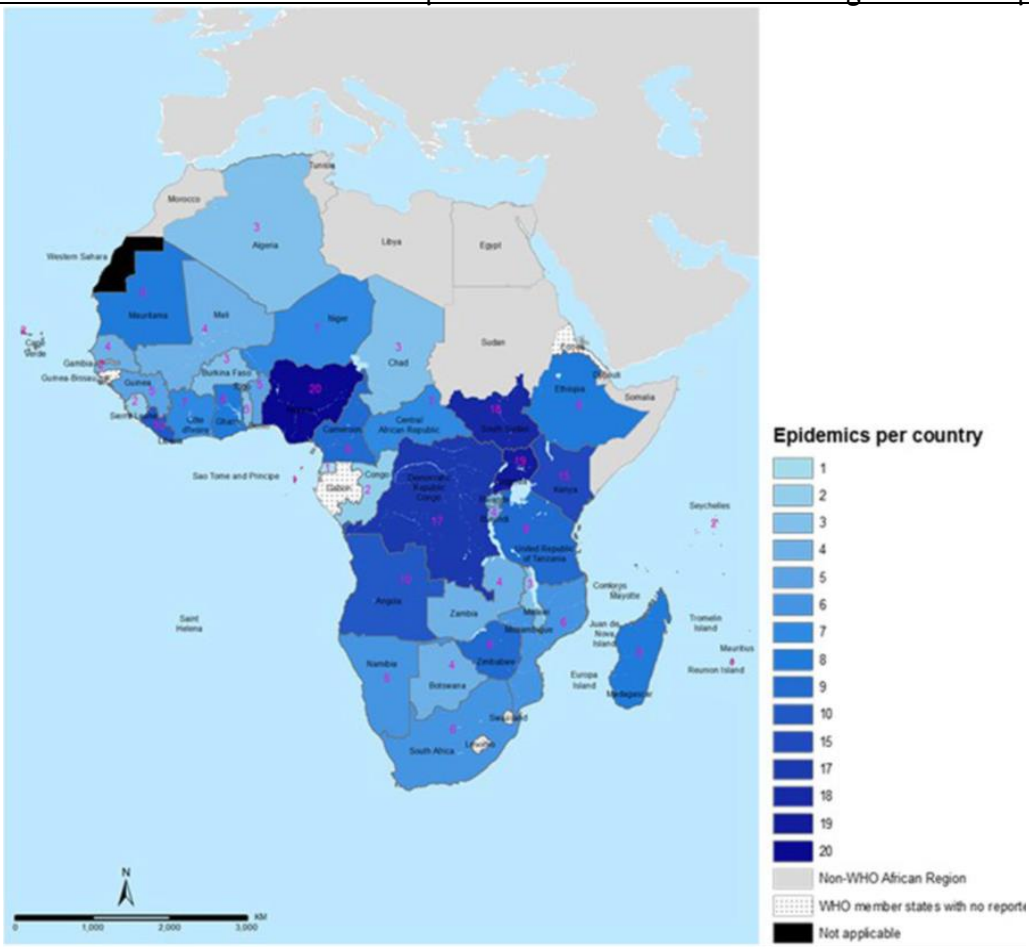

Figure 1: Number of epidemics and other public health emergencies in the WHO African Region, 2016–2018
Source: Talisuna *et al* (2020)

In addition, the principal objective of spatial epidemiology is the prevention and management of diseases, whereby a significant area of inquiry is focused on the spatial distribution of diseases (Saran *et al*, 2020).

METHODS

The Study Area

Owo Local Government Area (LGA) stands as one of the eighteen (18) LGAs situated within Ondo State. Positioned between latitudes 7^0 11' 46" and 7^0 15' 32" North on the Equator, and longitudes 5^0 35' 12" and 5^0 18' 40" East of the Greenwich Meridian, the area encompasses a total land expanse of approximately 636 sq. km (Macmillan, 2006) and is home to an estimated population of 218,886 (NPC, 2006). According to projections based on the 2006 population census, the

population was expected to reach 316,947 by the year 2023. Owo LGA shares its boundaries with Emure-Ise Orun LGA of Ekiti State to the North, while Akure and Idanre lie to the East and South respectively. To the West and part of the South, Ose LGA serves as the demarcation line. The natural boundaries between Owo and some neighboring LGAs are delineated by River Ogbese and Ose.

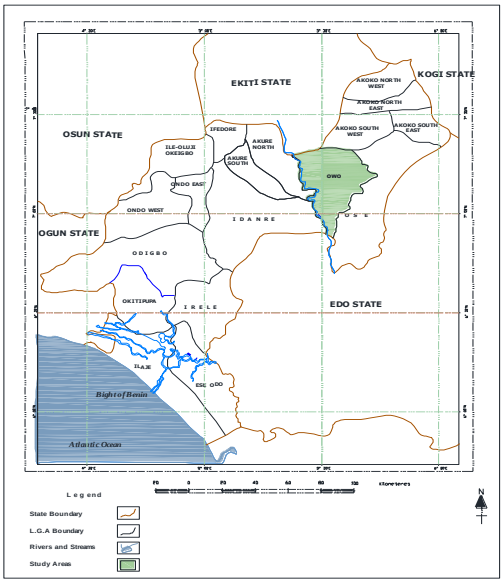

Figure 2: Ondo State in the National Context **Figure 3:** Owo LGA in the Regional Context
Source: Ministry of Physical Planning and Urban Development, Ondo State, 2023

RESEARCH METHOD

A multi-stage sampling technique was used. The initial stage encompassed the purposeful selection of one local government area (LGA) from the six LGAs present in Ondo North. Owo LGA was selected based on the premise that it possesses a greater number of healthcare facilities and is the most urbanized local government area within Ondo North Senatorial Districts. Owo LGA has 7 urban political wards, 4 of these urban political which is 50% were selected. The selected political wards are: Ehinogbe, Isaipen, Igboroko II, Iloro with 12,466 household heads. Also, 10% of the 127 rural settlements were randomly selected comprising of 14 rural settlements which are: Iyere, Isuada, Ipele, Omolege Camp, Eporo, ItaIpele Camp, Sasere Camp I, Obasooto Camp, Ilale, Isijogun Camp, Ipenmen Camp I, Oliyere Camp, Ago Panu, Olubola Camp with 9,095 household heads. This according to NPC, (2006), settlements containing a population exceeding 20,000 individuals are categorized as urban, whereas those with a population below 20,000 are designated as rural settlements. Furthermore, 1.5% of the total household heads, 187 in the urban areas and 136 in the rural settlements were interviewed using systematic random sampling techniques (Table 1). The use of 1.5% (323) sample size is reasonable considering the fact that in similar studies, a sample size of 1.2% was used by Akinbamijo (2004) on environmental health and intra urban

disparities in Akure metropolis and got good results. Olugbamila, (2016) researched on the distribution and patronage patterns of healthcare facilities in Ondo State and used a sample size of 1.5%. The sample size was used in order to have a reliable and manageable size and to capture the interest of the population in the study area. The first residential building in each settlement was selected, while every 50th residential building was also chosen for questionnaire administration. Structured questionnaire, focus group discussion, and direct observations were used to source information from residents of the study area

Table 1: Settlements and number of household heads selected for interview in the study area

LGA	Settlements Category	No. of Settlements	Selected Rural Settlements (10% of iii)	Selected Urban Settlements (50%of iii)	Household Population	Total No. of House hold heads	Sample Size (1.5%of vii)
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Owo	Urban	7		4	62,333	12,466	187
	Rural	127	14		40,475	9,095	136
Total		**134**	**18**		**102,808**	**21,561**	**323**

Source: National Population Commission, 2006; Authors' compilation, 2023.

As indicated in Table 1, a total number of 323 households were subjected to be interviewed. However, only 293 surveys (187 from the urban areas and 136 from the rural settlements) were retrieved due to the reluctance of certain respondents to reveal the health condition of their families, particularly when the household head was unavoidably absent. Additionally, some individuals perceive such disclosure as taboo and contrary to their beliefs and traditions.

Secondary data sourced from relevant public and private healthcare facilities on malaria cases in the study area such as Federal Medical Centre, Owo, Comprehensive Health Centre, Emure Ile, Basic Health Centre, Ijebu Owo, and other privately owned healthcare facilities among others were utilized. The residential areas are used as the input feature class, while the number of malaria cases in each residential settlement within the study area during the reviewed year serves as the input field for the analyses. For the data analysis, a geospatial tool within the ArcGIS was used to conduct spatial analysis of the data acquired. This tool proved invaluable in revealing the spatial pattern of malaria cases within the study area, as well as facilitating cluster/outlier and hotspot/coldspot analysis. According to Tabb (2018), the spatial distribution of diseases is often characterized by the presence of spatial patterns, which possess the capability to prognosticate spatial transmission dynamics. These spatial patterns serve as indicators of broader epidemic trends at which malaria propagates. To investigate the presence of spatial clustering or dispersion, hot spot and cold spot the dataset was examined using the Global Moran's Index. Since the minimum sample size for spatial analysis is 30 (Moran, 1950), therefore, 59 urban and rural residential settlements were randomly selected for spatial analyses. The residential areas were utilized as the input feature class, while the number of disease occurrences in the year under review in each residential settlement within the LGA served as the input field for the analyses.

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RESULTS AND DISCUSSION

Pattern and distribution of malaria cases in Owo LGA

In the study area, malaria is the foremost prevalent ailment spanning the entirety of the 59 selected urban and rural communities. Based on the records of reported cases of malaria in Table 2, the findings as evidenced in Figure 4, unveil the preponderance of malaria within the urban core residential area of Owo. The settlements with the highest incidence of malaria are the densely populated urban areas of Isaipen and Ijebu, where figures ranged from 364 to 665 cases per annum. Other settlements, including Iyere, Ipele, Isuada, and a select few others, are also situated within the high-density urban areas, where they annually record between 63 and 363 cases of malaria. Other high-density settlements witnessed an annual range of 32 to 62 cases of malaria. The occurrence rate of malaria is relatively reduced in rural areas characterized by medium and low population densities. In areas with medium population density such as Isewe, Uso, Olumide, Olefah, Emaojomo, Sasere, Odeya, and several others, the annual number of malaria cases ranged from 13 to 31. Conversely, the incidence of malaria in rural areas with low population density like Elepo, Josiah, Bogoubo, Ojugbere, Iloro, and others was found to be very limited, with a recorded annual range of 0 to 12 cases. The results demonstrate that the frequency of malaria is higher in the urban areas of Isaipen and Ijebu, characterized by dense populations that promote increased transmission through vectors via stagnant dirty water and poor environmental care.

Table 2: REPORTED CASES OF MALARIA FROM JANUARY - DECEMBER, 2023 IN THE STUDY AREA

S/No	Urban Settlements	Malaria cases	S/No	Rural Settlements	Malaria cases
1.	Ipele	198	30.	Ologede	26
2.	Iyere	205	31.	Rufus	18
3.	Ehinogbe	665	32.	Ajebamidele	9
4.	Igboroko II	363	33.	Ladokun	27
5.	Ijebu	290	34.	Baga	21
6.	Isaipen	282	35.	Ago-Panu	19
7.	Igboroko I	479	36.	Elepo	18
8.	Isuada	224	37.	Amurin	6
9.	Ipeme	157	38.	Egbeda	17
Rural Settlements			39.	Odeya	25
10	Alesha-Ashamo	16	40	EmiIloro	44
11	Ipaso	44	41	Bogunbo	28
12	Uso	41	42	Emaojomo	19
13	Obaseki	21	43	Isewe	18
14	Sasere	23	44	Ijegunmo	56
15	Elemile	29	45	Ilale	39
16	Emure-Ile	37	46	Osijogun	62
17	Okele Camp	31	47	Oludemi	16

18	Araromi	31	48	Adawanran	25
19	Ajifuwan	25	49	Abusoro	38
20	Sajiyan	14	50	Orugbe	11
21	Ero	24	51	Okundara	39
22	Alajo	25	52	Omokehin	19
23	Oluka	24	53	Gbeta	18
24	Owalaye	26	54	Obasoto	41
25	Lalupon	30	55	Alasha	28
26	Arere	18	56	Asaba Odo	0
27.	Ubale	28	57	Ojugbere	12
28.	Bale	15	58	Olefah	28
29.	Josiah	24	59	Alesaluwala	12

Source: Records on malaria cases from selected public and private healthcare facilities in Owo LGA, 2023

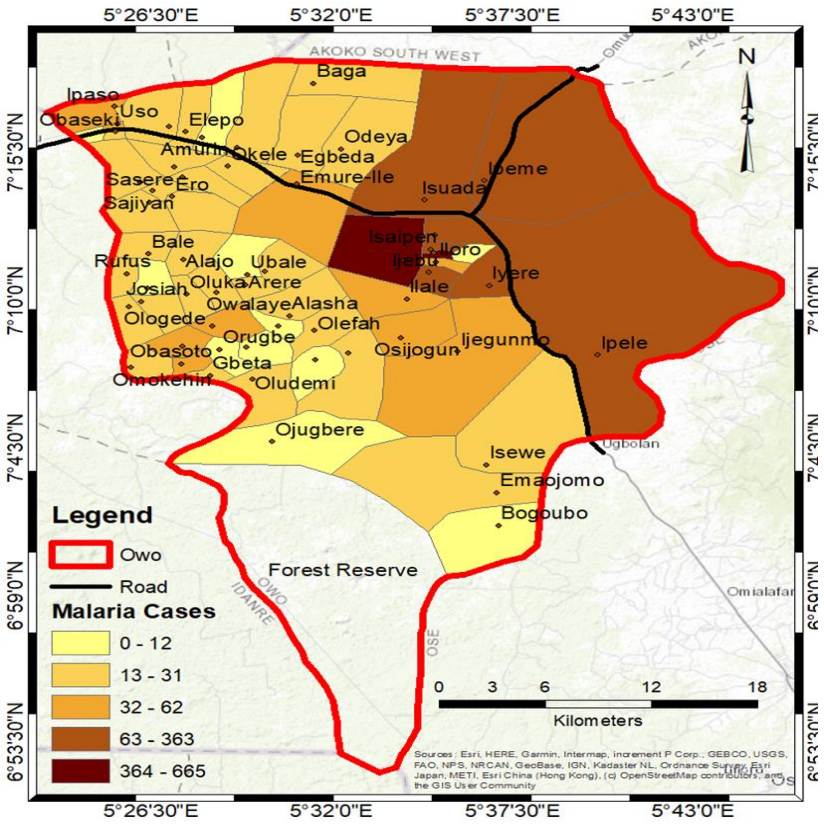

Figure 4: Distribution of malaria cases in Owo LGA
Source: Author's compilation, 2023

The map displayed in Figure 5 shows that there is a notable cluster of high incidence of malaria in the high-density urban areas, where settlements with high malaria cases are located in close proximity to one another. Conversely, the low incidence of malaria is observed in certain areas of the low and medium-density rural areas, forming a distinct cluster. Furthermore, the hotspot and coldspot map presented in Figure 6 illustrates that the areas with the highest incidence of malaria are concentrated in the high-density urban areas, specifically in locations such as Isuada, Ipeme, Isaipen, Iloro, and Ilale, among others. On the other hand, the areas with the lowest incidence of malaria are predominantly found in the low and medium-density rural areas, including Uso, Bale, Rufus, Gbeta, Obasoto, Oluka, Arere, and other similar locations. Moreover, the spatial autocorrelation metrics depicted in Figure 7 revealed a minimal level of malaria cases clustering in the urban residential areas of Owo LGA, with a Moran's I Index of 0.419874 and a z-score of 8.737030. It is important to note that values exceeding 2.58 are deemed clustered at a significance level of 0.01. The low clustering of malaria occurrences is specific to the residents of Isaipen and Ijebu, which may be attributed to the population size of these areas in comparison to other urban areas. The significance of urban planning reveals that Isaipen and Ijebu, situated in the central area of Owo, exhibit inadequate environmental governance practices; thus, there is a necessity for improved environmental surveillance and educational initiatives targeting the fundamental causes of malaria.

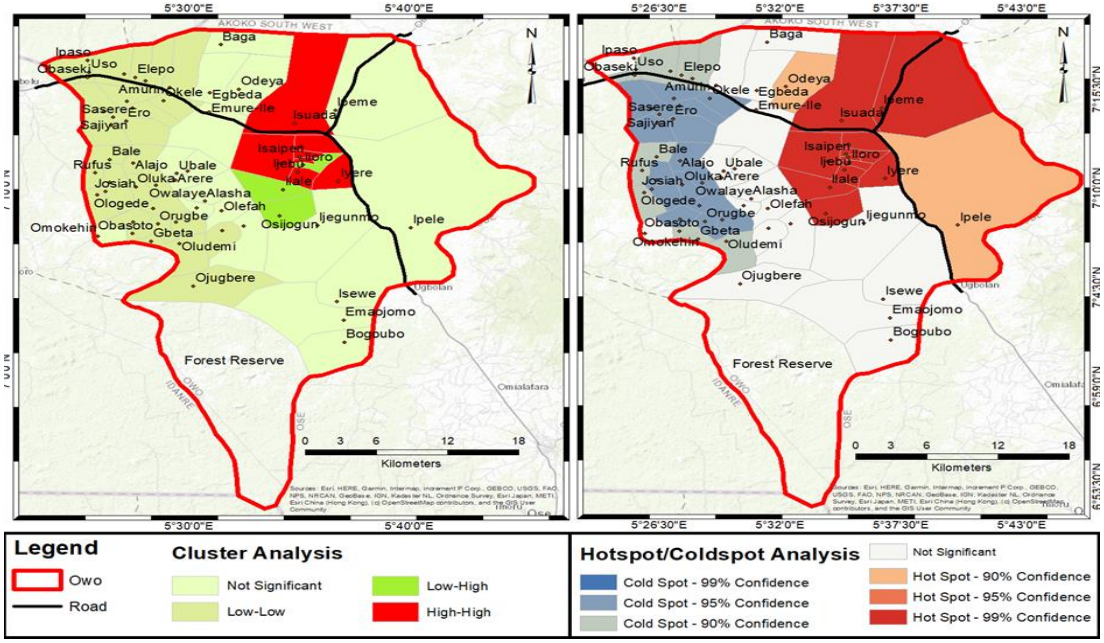

Figure 5: Cluster/Outlier Map
Source: Author's compilation, 2023

Figure 6: Hotspot and Coldspot Map
Source: Author's compilation, 2023

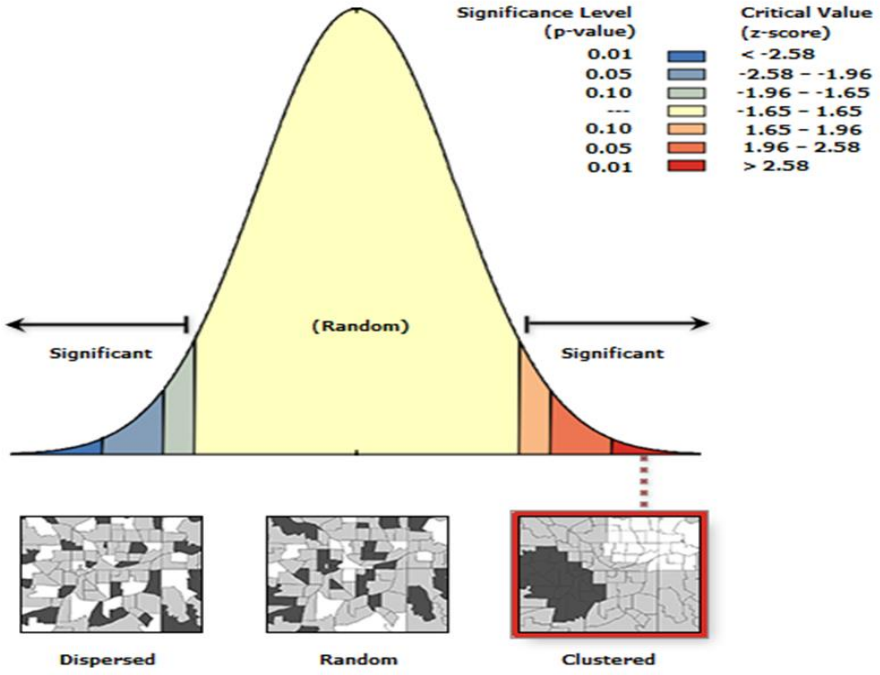

Figure 7: Spatial autocorrelation of malaria disease in Owo LGA
Source: Author's compilation, 2023

The analyses presented in Figures 4, 5, 6 and 7, reveal that areas with a high population density exhibited a substantial number of malaria cases, whereas areas with a low population density experienced low cases of malaria. Furthermore, on the cluster analysis, the densely populated areas demonstrated a pattern of high-high and low-high, in contrast to the sparsely populated areas which displayed a pattern of low-low and insignificance. The examination of hotspots and coldspots revealed that the densely populated areas fell within the 99% confidence level hotspot, as well as the 95% confidence level hotspot. Similarly, the sparsely populated areas were identified as a coldspot with a 99% confidence level and a 95% confidence level.

Mode of solid waste disposal

The results presented in Table 3 show that in Owo LGA, the method utilized for solid waste disposal in urban areas indicates that 47.7% of the respondents engage in open dumping. Furthermore, 31.6% employ open burning and incineration methods while 20.7% rely on waste collectors. In the rural areas, 80.7% of the respondents practice open dumping, 19.3% resort to open burning and incineration methods, and none of the respondents have access to waste collectors. These findings reveal that open dumping, which accounts for 61.1%, is the prominent method of waste disposal in Owo LGA. Consequently, open dumping of solid waste is the most common practice, creating a favorable environment for rodents, flies, mosquitoes, snakes, and other dangerous animals, while also causing significant environmental degradation and a multitude of health hazards including malaria. These findings support the claims made by Onuegbu (2024)

that failure to take appropriate measures in solid waste disposal and management increases the risk of exposure to pathogens, which in turn can lead to significant health hazards such as communicable diseases.

Table 3: Mode of solid waste disposal in the study area

Owo LGA	Open dump	Open burning/incineration	Waste collector	Total
Urban	83 (47.7%)	55 (31.6%)	36 (20.7%)	**174 (100%)**
Rural	96 (80.7%)	23 (19.3%)	0 (0.0%)	**119 (100%)**
Total	**179 (61.1%)**	**78 (26.6%)**	**36 (12.3%)**	**293 (100%)**

Source: Author's compilation, 2023

Management of wastewater in the study areas

As presented in Table 4 in the urban areas of Owo LGA, the management of wastewater was characterized by the utilization of soak-away pits (27.0%), drains (20.7%), and open spills (52.3%). Conversely, in the rural areas, soak-away pits accounted for 13.4%, drains revealed a percentage of 5.1%, and open spills constituted a significant proportion of 81.5%. The findings indicate that both urban and rural residents of Owo LGA predominantly engage in open spills as their preferred method of wastewater management, accounting for 64.2%. Improper disposal of wastewater from bathrooms, laundries, and kitchens in study area results in foul odors as well as unsanitary environments and creates breeding grounds for mosquitoes.

Table 4: Management of wastewater in the study areas

OwoLGA	Soak-away pit	Drains	Open spills	Total
Urban	47 (27.0%)	36 (20.7%)	91 (52.3%)	**174 (100%)**
Rural	16 (13.4%)	6 (5.1%)	97 (81.5%)	**119 (100%)**
Total	**63 (21.5%)**	**42 (14.3%)**	**188 (64.2%)**	**293 (100%)**

Source: Author's compilation, 2023

The secondary data obtained from healthcare facility operators regarding malaria cases in rural residential settlements indicated a relatively low prevalence. However, findings from Focus Group Discussions (FGDs) with a majority of the rural residents revealed that malaria is a significant health challenge in their communities. This is as a result of increase in mosquitoes resulting from stagnant dirty water, buildup of waste, unhygienic environment, close proximity to streams, and various other influencing elements. Also, poor environmental education and awareness on diseases and environmental management on the part of environmental sanitation officers. It is important to reveal that the insufficiency of healthcare facilities and personnel in numerous rural communities played a significant role in the underutilization of the existing healthcare resources. However, in rural settlements with healthcare facilities, the distance travelled and the poor road conditions reduce the patronage of the healthcare facilities. Additionally, the high cost of treatment compared to the income of the rural residents further contributed to the low patronage. Consequently, many individuals in rural settlements resorted to alternative methods of malaria treatment, such as herbal remedies, visits to chemist shops, seeking assistance from spiritual healers, or purchasing medicine

from vendors. These alternative methods of malaria treatment in rural settlements resulted in low records on malaria cases in the rural communities of the Owo LGA.

CONCLUSION AND RECOMMENDATIONS

The environmental challenges in Nigeria are severe, widespread, and rapidly increasing. This percentage is even higher in impoverished conditions, where individuals are exposed to a greater number of environmental hazards in their living environments; while having limited ability to protect themselves against the negative effects of these conditions. This situation should be a cause of significant concern for society as a whole. It is on this premise; that this study examined the spatial arrangement and dispersions of malaria cases in Owo LGA. Findings revealed preponderance of malaria within the urban core area; open dump of solid waste is being practice by the majority of the residents; predominant among the residents in wastewater management is through open spill. The deteriorating health conditions in the study area as a result of insufficient environmental management capabilities, are fundamental factors that contribute to malaria disease in the study area. Based on these findings, the following recommendations are proposed in order to improve on the quality of health of the residents in the study area: through the establishment of a dedicated agency called Environmental Monitoring Agency to monitor solid waste and wastewater management in the study area. This agency could be a governmental or community based agency who can lead in organizing awareness campaigns and community engagement initiatives to educate residents on how to improve on access to a safe and high-quality environment, suitable sanitation on wastewater and solid waste disposal methods, and encouraging hygienic behaviors. Through these, the health challenges of malaria can be mitigated.

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