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## **Analysis of the Distribution Pattern of the Incidence of Malaria Disease In Akwa Ibom State, Nigeria**

by

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### **Abstract**

*This study analyzed the distribution pattern of the incidence of malaria disease in Akwa Ibom State, Nigeria using geographic information systems techniques. Data on the incidence of malaria in the area was collected from secondary source-mainly from the Ministry of Health, Akwa Ibom State. The data was mapped using statistical and choropleth mapping techniques in a GIS environment. The result indicated that, they were seven categories of malaria disease in the area. Out of this number, three were high in number of cases and wide spread and could be regarded as major. Furthermore, out of the three major categories studied, two were randomly distributed and the distribution pattern of one of the categories clustered. The development and use of GIS for mapping to enhance targeting the sick was one of the recommendations to eradicate/reduce the incidence of malaria disease in the Study area.*

### **1. Introduction**

Malaria is one of the diseases with high fatality rates in tropical countries. Kaur, (2019), asserts that malaria usually results from bites of mosquitoes of the *Anopheles* spp. Chukwuocha *et.al* (2012), writes that globally, malaria causes about 500 million cases and one million deaths every year. It consistently remained a disease of high burden in most developing countries including those in Africa. As a result of this, it negatively impacts on the economy of the already struggling developing countries (WHO, 2018).

Mills, (2008), observed that malaria is highly prevalent in Nigeria where young children and pregnant mothers are the most affected according to reports. Selvaraj, *et al.* (2019), writes that African Heads of government, met in Abuja, Nigeria on April 25, 2000, to express commitment to the Roll Back Malaria (RBM) initiative because of the economic burden the disease has placed on the continent. Okeke (2012), states that at the Abuja meeting, malaria surveillance was identified as key to reducing the burden of malaria and its control.

Studies indicate that the African region bears the largest burden of malaria morbidity and mortality, with an estimated 215 million malaria cases and 384,000 malaria deaths accounting for about 94% of cases and deaths in 2019 (Dougnon *et al.*, 2015; Onah *et al.*, 2017; WHO, 2020). Moreover, malaria disease remains a complex and overwhelming public health problem in the world's poorest countries including Nigeria. Sub-Saharan Africa is home to localities suffering from the highest malaria transmission levels and its consequent morbidity and mortality (WHO, 2018, WHO, 2020; WHO/RBM/UNICEF, 2005).

Furthermore, studies report that malaria is a disease of poverty and underdevelopment. Malaria and poverty are strongly connected, often inextricably intertwined. As both a cause and a consequence of poverty, malaria is most intractable for the poorest countries and communities in the world that face a vicious cycle of poverty and ill health (Gallup & Sachs 2001; Sachs and Malaney 2002; WHO/UNICEF 2003; WHO, 2002). The relationship between poverty and malaria has long been recognized but its paths are multiple and complex. Recent studies suggest that causality works both ways (Gallup and Sachs, 2001; Sachs and Malaney 2002; WHO/UNICEF 2003; WHO, 2002). The foregoing calls for action from all and sundry to tackle the disease of malaria in any area with all the men and materials at its disposal in order to ensure sustainable human development among other things.

Experts agree that, 'today's children are the leaders of tomorrow' (Walker, 2016; Daum, 2013; Aliya, 2022). This implies that the future of any country depends to a large extent on the young ones (the children). Any disease that keeps killing them is, therefore, a threat to the sustainable development of such a country. Unfortunately studies show that malaria is a killer of children under five years of age (WHO, 2011; WHO, 2012; WHO, 2020, Mills 2008; Dougnon *et al.*, 2015 and WHO, 2021).

According to the 2021 World Malaria Report, Nigeria has the highest number of malaria cases (27 % of global malaria cases) and the highest number of deaths (32 % of global malaria deaths) in 2020. The country accounted for an estimated 55.2% of malaria cases in West Africa in 2020. Case number increased by 5.3% between 2017 and 2020, from 298 to 314 per 1000 of the population at risk. Deaths increased by 4.7%, from 0.92 to 0.97 per 1000 of the population at risk during that same period (WHO 2021).

In Akwa Ibom State, malaria cases increased from 35,398 in 2004 to 64,290 in 2008 growing at an average annual rate of 20.66%. According to the recent National Demographic Health Survey, the prevalence of malaria in children under the age of 5 in Akwa Ibom State was 23.3 percent as against 27 percent that was recorded in 2015. It is obvious from the foregoing that despite the reduction being recorded in the incidence of malaria over the years, malaria is still one of the most serious vector-borne diseases (VBDs) and remains a leading cause of morbidity and mortality in the world and indeed Akwa Ibom State of Nigeria. Moreover, in areas where transmission is higher, malaria remains the major cause of death for children under five years of age, ending a life every two minutes according to UN (2020).

Furthermore, Geospatial technology has been widely used to study the risk and factors associated with malaria hazard (Odhiambo *et al.* 2020; Olagundoye and Goparaju,

2023). According to Epstein *et al.*, (2023), maps of malaria risk are important tools for allocating resources and tracking progress. Hay and Snow (2006), assert that resource allocations for malaria interventions remain driven by perceptions and politics, rather than an objective assessment of need. This deplorable situation is untenable when global, national and regional financial resources must be defined to meet needs for new, expensive antimalarial drugs and commodities to prevent infection and to ensure that these interventions are optimally targeted. It has been long, almost 40 years since the last global map of malaria endemicity was constructed and a decade since the need for maps of malaria transmission in Africa was first advocated. Although substantial progress has been made, an evidence-based map of malaria transmission intensity for Africa remains elusive, and there have been no recent efforts to construct a credible evidence-based malaria map in Akwa Ibom State, Nigeria. Once such maps are created, the maps will provide a baseline to facilitate estimation of populations at risk of malaria and more-credible predictions of disease burden. Such maps will also provide a platform to help target intervention needs, and may provide a means to measure progress toward national and international malaria public health goals at a global scale. As we have argued, such maps may also provide a means to help determine the distribution of intervention types and mixes within an area among other things.

The aim of this study was to analyze the distribution pattern of the incidence of malaria diseases in Akwa Ibom State, Nigeria using geographical information systems [GIS] techniques/technology. This was achieved through the following objectives the determination and mapping of the incidence of malaria disease in Akwa Ibom State and the analysis of the distribution pattern of the incidence of malaria disease in Akwa Ibom State.

## **2. Materials and Methods**

### ***Location of the Study Area***

Akwa Ibom State is situated in south eastern Nigeria. It lies between latitudes 4°30' and 5°30'N and longitudes 7°30' and 8°15'E (Fig.1). It is bounded in the south by the Atlantic Ocean, in the North West by Abia State, east by Cross River State and South West by Rivers State. The State occupies a total land mass of 7245. 935 sq.km.

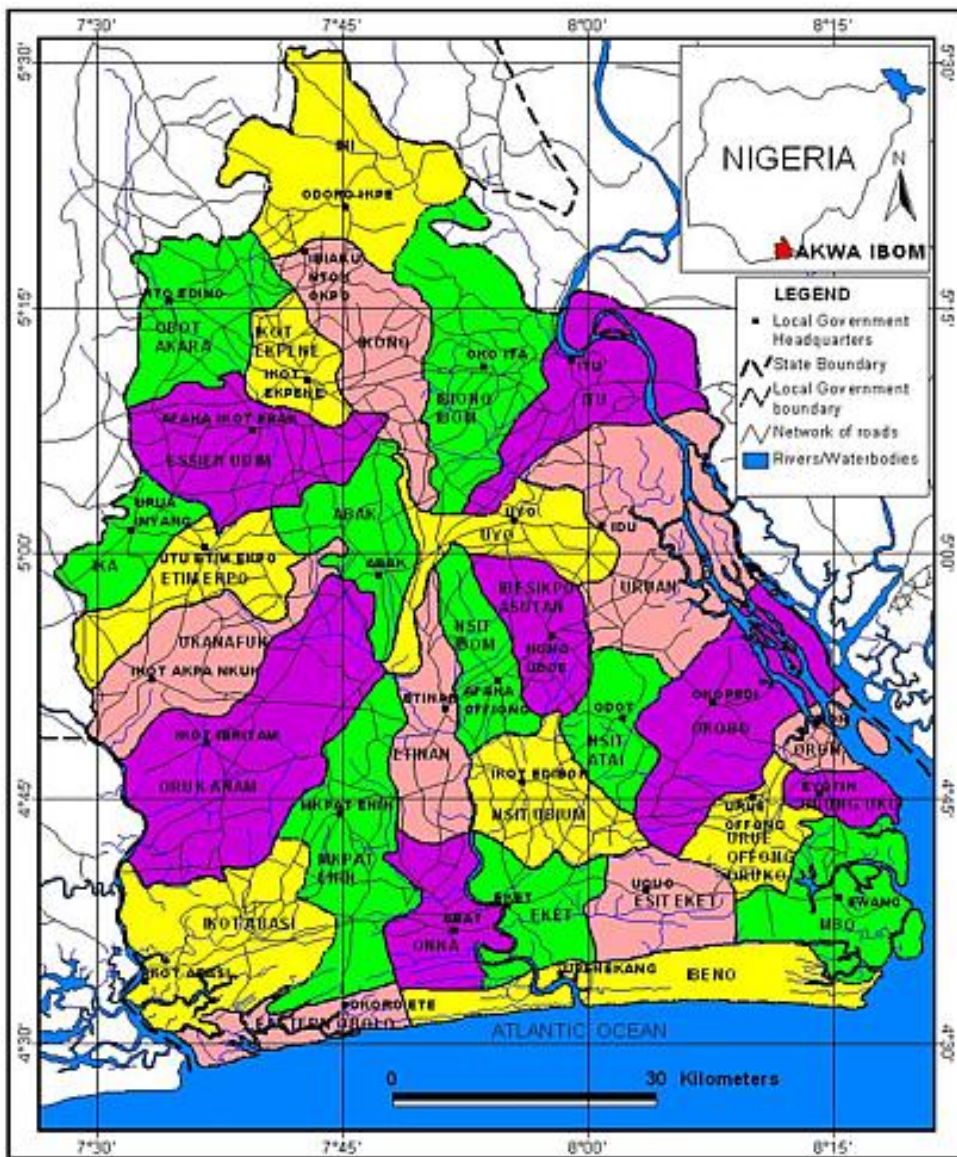


Fig. 1: Location of Akwa Ibom State, Nigeria

Source: Akwa Ibom State Surveys, 1997.

### Types and Sources of Data

The data on the incidence of malaria was collected from secondary source, mainly the Ministry of health, Akwa Ibom State.

### Methods of Data Analysis

To map malaria incidence in order to reveal its pattern of distribution, choropleth and statistical mapping techniques were adopted. According to Robinson, *et al.*, (1995), choropleth map is a map where geographic regions or administrative divisions are colored, shaded, or patterned in relation to a value. It is a technique of depicting the variations with

the help of different shades or designs which indicate very low, low, medium, high and very high values of distribution of data. Statistical mapping on the other hand comprise graphs on a map background. This allows for more details to be shown on the map. In this study for example, it was possible to show incidence of malaria in terms of age group basis (i.e. below and above 5years old).

To analyze the pattern of distribution of the incidence malaria disease in the study area, spatial autocorrelation (Moran's I) was used to test hypothesis 1. Spatial autocorrelation is a method that can be used in detecting spatial patterns of point distribution by considering both the locations of the points/areas and their attributes [in this case, Malaria incidence]. Spatial autocorrelation of a set of points/ areas is therefore concerned with the degree to which points or things happening at these points/ areas are similar to other points or phenomenon happening there. This makes it possible to determine whether the pattern of distribution is clustered, dispersed or random (Getis and Ord, 1992; Mitchell, 2005).

In this study, data on the incidence of the three major categories of malaria incidence in Table 1 was used as input in the spatial autocorrelation [Moran's I] tool in the ArcGIS software environment. A Moran's I index value of + 1.0 indicates clustering, while an index of - 1.0 indicates dispersion. However, it is necessary to look at the Z score in order to take a decision. If the Z score is between -1.96 and +1.96, the null hypothesis cannot be rejected. When this happens, the pattern could very likely be one version of a random pattern. If the Z score falls outside that range e.g. -2.5 or +5.4, the pattern exhibited is too unusual to be just another version of random chance. If this happens, then the null hypothesis is rejected. However, the reason for the unusual pattern must be figured out (Getis and Ord, 1992; Mitchell, 2005).

### **3. Results and Discussion**

#### ***The determination and mapping of the Incidence of Malaria Disease in Akwa Ibom State***

Table 1 presents the reported cases of malaria in the State in 2023. The table reveals the fact that there were seven different categories of malaria incidence in Akwa Ibom State during the period under review.

These categories included the following:

1. Severe malaria
2. Uncomplicated malaria
3. Clinically diagnosed malaria
4. Malaria presenting with fever tested by RDT
5. Malaria presenting with fever tested by microscopy
6. Malaria tested positive by RDT
7. Malaria tested positive by microscopy

Severe malaria occurs due to delayed treatment of uncomplicated malaria and is defined by clinical or laboratory evidence of vital organ dysfunction or abnormalities in the patient's blood or metabolism. It is also defined by the presence of Plasmodium falciparum parasitemia (90 percent) and can be life-threatening (WHO, 2022).

Table 1: Reported cases of the incidence of malaria disease in the State in 2023

Local Government Areas	Severe Malaria cases <5yrs	Severe Malaria cases ≥5yrs	Uncomplicated Malaria Cases <5yrs	Uncomplicated Malaria Cases ≥5yrs	Persons with clinically diagnosed Malaria <5yrs	Persons with clinically diagnosed Malaria ≥5yrs	Persons presenting with fever & tested by RDT <5yrs	Persons presenting with fever & tested by RDT ≥5yrs	Persons presenting with fever and tested by Microscopy <5yrs	Persons presenting with fever and tested by Microscopy ≥5yrs	Persons tested positive for malaria by Microscopy	Persons tested positive for malaria by Microscopy ≥5yrs	Persons tested positive for malaria by RDT <5yrs	Persons tested positive for malaria by RDT ≥5yrs
Abak	15	15	2315	8320			5366	18320	44	352	35	206	2296	8129
Eastern Obolo	4	10	646	2430			1232	4388					647	2443
Eket	205	431	1565	7234	27	119	3902	11102	1287	5561	543	2678	1229	5008
Esit Eket	60	52	841	3224			1715	7055	14	91	8	26	904	3239
Essien Udim	5	18	1381	4071		1	3626	10238	148	466	75	283	1319	3868
Etim Ekpo	8	23	1530	4192	5	41	3356	10439	62	591	32	166	1499	4063
Etinan	46	57	2080	9958	11	81	5300	22025	5	118	2	39	2111	9955
Ibendo			935	3876			1989	7903	56	141	23	55	913	3821
Ibesikpo Asutan	1	1	1168	3847	35	61	3353	11542	7	6	7	6	1162	3842
Ibiono Ibom	55	135	931	3964			1905	5533	267	2119	201	1515	781	2588
Ika	9	7	1550	7285			4578	17952	4	8	3	3	1556	7289
Ikono	4	33	836	3569			1781	7135	4	35	4	35	859	3525
Ikot Abasi	89	140	1608	8601	46	244	2879	14429	242	806	169	564	1553	8167
Ikot Ekpene	83	200	1671	8405	21	190	3550	11259	939	4788	324	2397	1415	6215
Ini	4	8	1178	3816			1908	6178	5	26	3	13	1178	3810
Itu	3	9	1307	5594			4552	13362	41	236	42	209	1265	5387
Mbo			1964	5229			3011	9454	1	13	1	13	1963	5216
Mkpat Enin	11	9	1219	6046			2702	12180	3	114	2	39	1228	6016
Nsit Atai			775	2352			1601	5205					775	2352
Nsit Ibom			1289	8366			3704	23481					1289	8366
Nsit Ubium	5	9	1121	3577			2112	6984	2	4	2	4	1133	3582
Obot Akara			3002	10077			6382	20347					3002	10077
Okobo	18	21	1032	3202	4	8	1734	5286	46	161	22	76	1023	3157
Onna	18	37	1914	12536			5148	26821	1	10	1	4	1931	12569
Oron	62	46	2201	4343	199	657	5833	7976	371	1455	289	989	1993	3381
Oruk Anam	60	10	1624	7991	3	137	3162	12933	36	272	11	209	1594	7807
Udung Uko			813	2407			1278	3891					813	2407
Ukanafun			1335	4863	1		2800	9945					1335	4863
Uruan			1677	4166			3922	10773	5	163		64	1677	4102
Urue Offong Oruko			1708	5078			2590	7859					1722	5078
Uyo	8	11	3097	11625	142	1347	10379	18890	973	4833	488	2899	2609	8745

Source: Ministry of Health, Government of Akwa Ibom State, 2023

As shown in Table 1 and Fig.2. more of this category of malaria was found in Eket, Ibiono Ibom, Ikot Abasi and Ikot Ekpene LGAs among those that were above five

years of age. However, cases of Children below 5years of age in Eket was more than in any other LGAs.

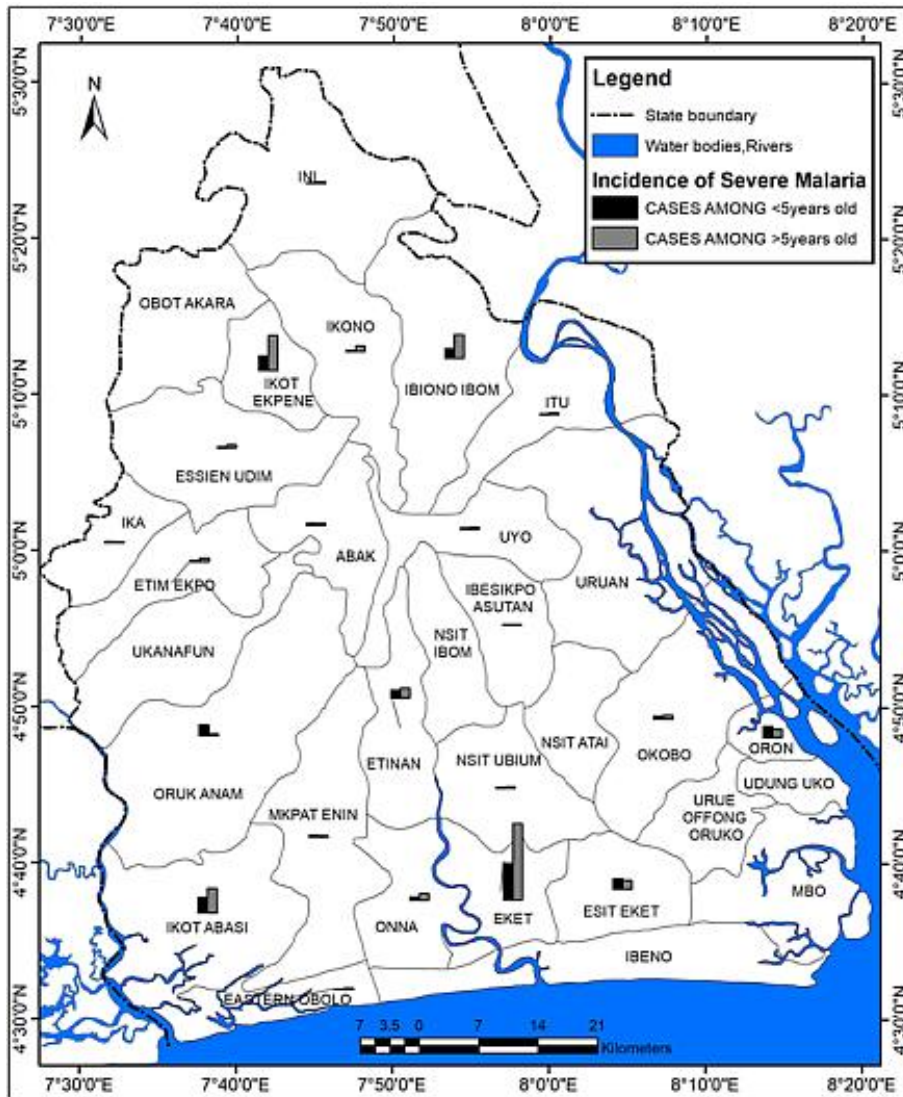


Fig.2. Akwa Ibom State: Incidence of severe malaria in 2023

Source: Table 1.

Uncomplicated malaria is defined as malaria symptoms with a positive test but no severe features (WHO, 2022). As shown in table 1 and Fig.3, almost all the LGAs recorded high reported cases of this category of malaria among those that were above 5 years of age.

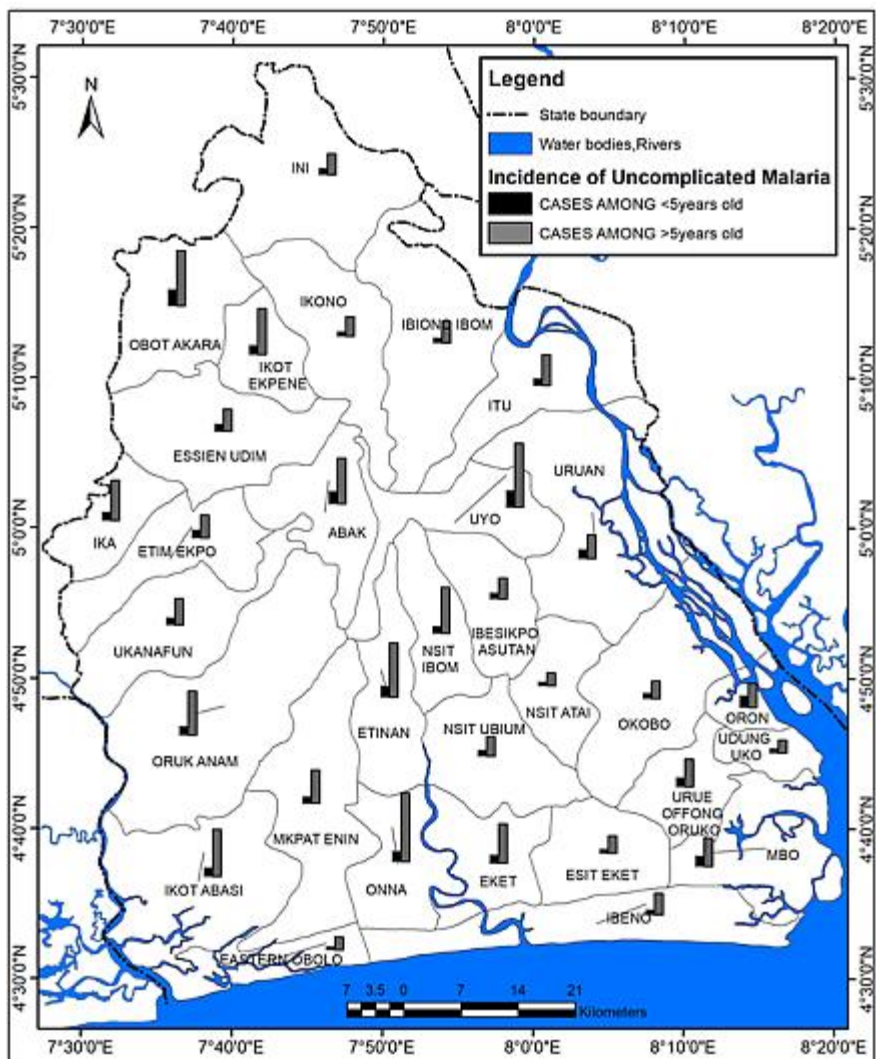


Fig.3. Akwa Ibom State showing distribution of cases of uncomplicated malaria in 2023  
 Source: Table 1.

Clinically diagnosed Malaria has to do with the situation in which the doctor reviews the medical history of the patient and recent travels, conduct a physical examination and order blood test. The test can confirm which type of malaria parasite is causing the symptoms among other things. It is obvious from table 1 and Fig. 4 that the numbers of cases in this category were relatively small and not common in most of the local government areas in the State.

Another category was malaria cases presenting with fever & tested by RDT. RDT means rapid diagnostic test. It is a way to test whether a person with malaria like symptoms actually has malaria. RTD assist in the diagnosis of malaria by providing evidence of the presence of malaria parasite in human blood. If the RDT is positive, it means that the person has falciparum malaria (WHO, 2022).



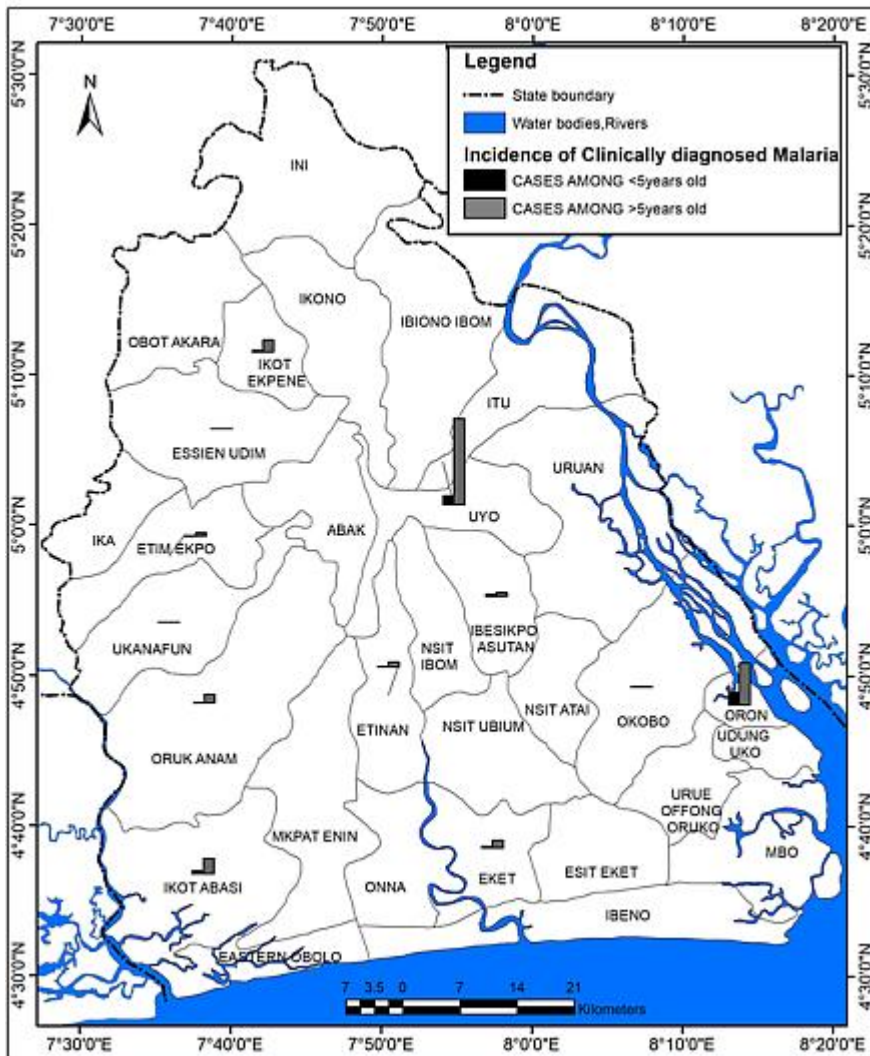


Fig. 4. Akwa Ibom State showing the distribution of persons with clinically diagnosed malaria in 2023

Source: Table 1.

It is obvious from table 1 and Fig. 5 that this category of malaria was wide spread in the state and it was reported more in Onna LGA in 2023.

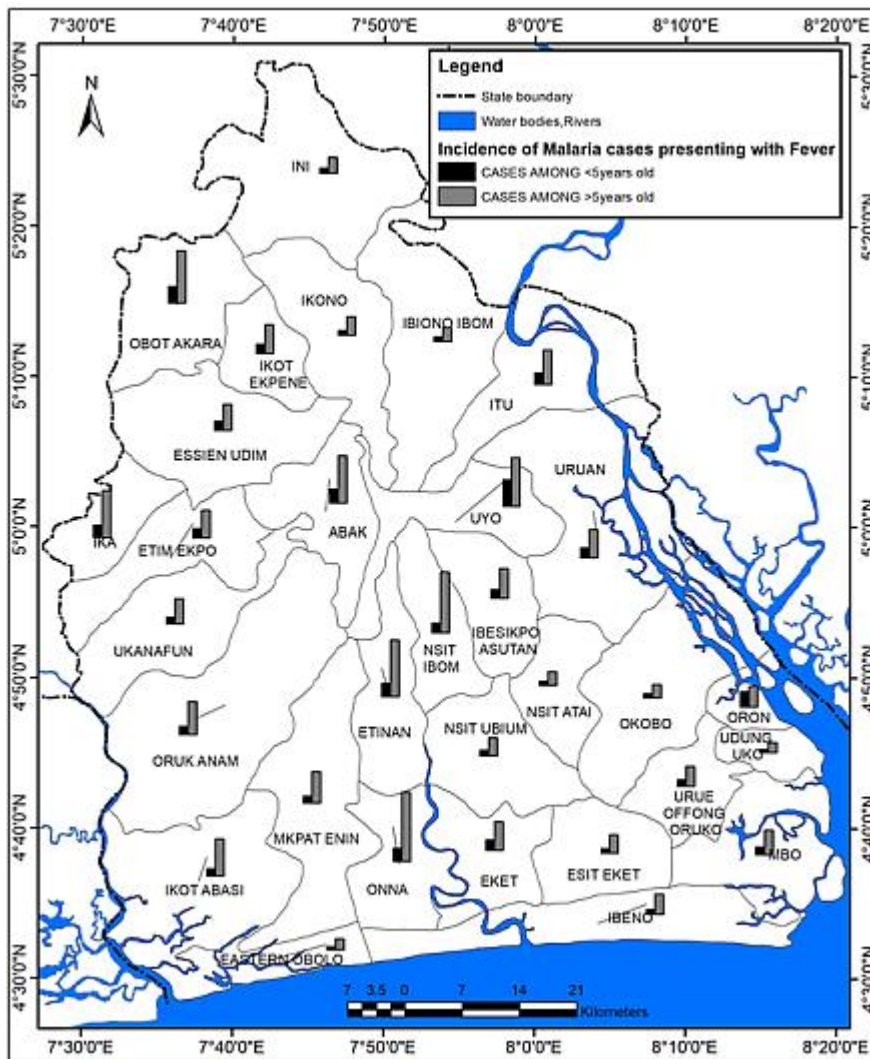


Fig. 5. Akwa Ibom State Showing distribution of cases of persons with malaria presenting with fever & tested by RDT in in 2023.

Source: Table 1.

Malaria cases presenting with fever & tested by Microscopy. Microscopy is the technical field of using microscope to view samples and object that cannot be seen with the unaided eye. It has to do with the examination of minute objects example malaria parasites by means of a microscope. It is obvious from Table 1 and Figure 6 that this category of malaria was not wide spread but very high in Eket, Ikot Ekpene and Uyo LGAs.

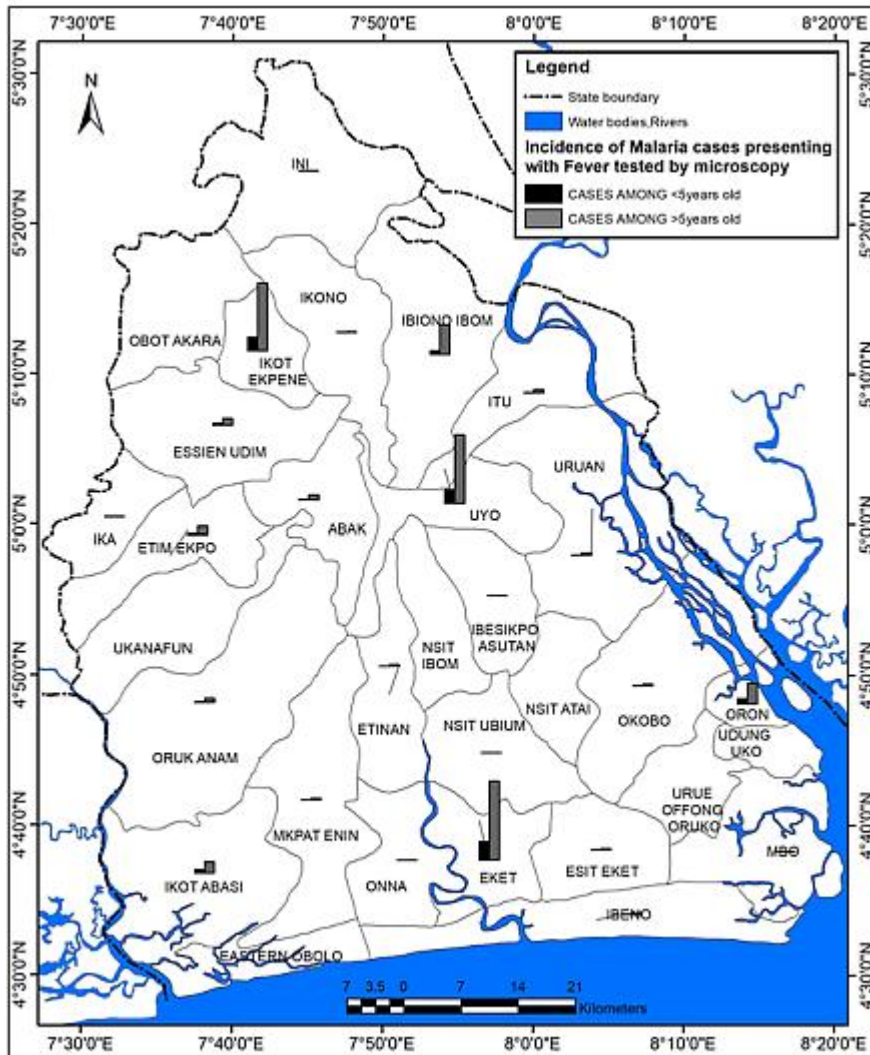


Fig. 6: Akwa Ibom State showing the distribution of persons with malaria presenting with fever tested by microscopy in 2023

Source: Table 1.

The number of persons who tested positive for malaria by RDT. It is obvious from Table 1 and Figure 6 that this category of malaria was wide spread in the State but very high in Onna LGA. It was also highest among children below the age of five [5] in Obot Akara LGA.

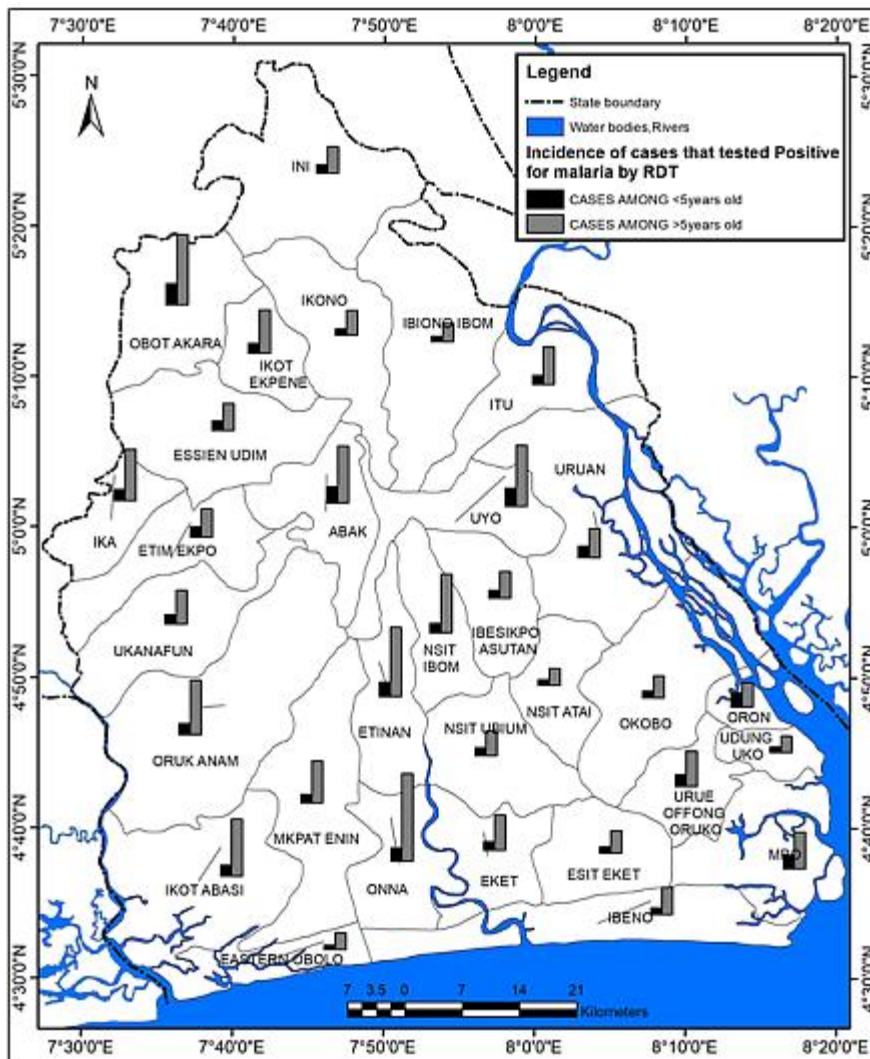


Fig. 7: Akwa Ibom State showing cases of persons who tested positive for malaria by RDT in in 2023.

Source: Table 1.

Number of Persons who tested positive for malaria by Microscopy. It is obvious from Table 1 and Fig. 8 that this category of malaria was not reported in six LGAs in the State but was very high in Uyo, Eket and Ikot Ekpene LGAs.

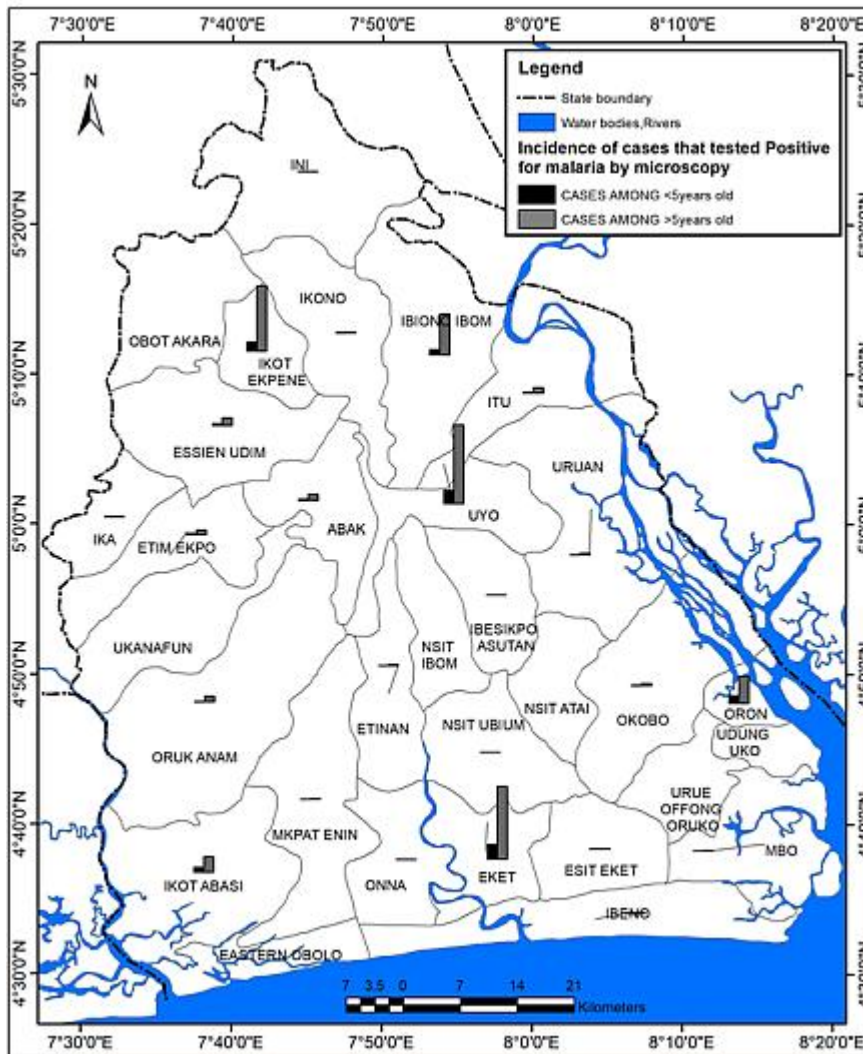


Fig. 8. Akwa Ibom State showing cases of persons who tested positive for malaria by Microscopy in 2023

Source: Table 1.

**Determination of the Distribution Pattern of the Incidence of Malaria Disease in Akwa Ibom State**

This was carried out using the three major categories of malaria in the area namely:

1. Malaria tested positive by RDT
2. Malaria presenting with fever tested by RDT
3. Uncomplicated malaria

This was because they were no missing data or gaps in the datasets of these three categories of malaria. More so because the reason for the gaps or missing data were not explained in the publication.

The map Fig.9 reveals the pattern of distribution of those/cases that tested positive for malaria in the State in 2023. It is obvious that this number was high in Obot Akara, Uyo, Abak, Nsit Ibom, Etinan, Onna, Oruke Anam and Ikot Abasi LGAs. It was moderate in Ika, Ukanafun, Mkpato Enin, Eket, Mbo, Urue Offong Uruko, Uruan and Itu. Other LGAs were locations where the incidence was low.

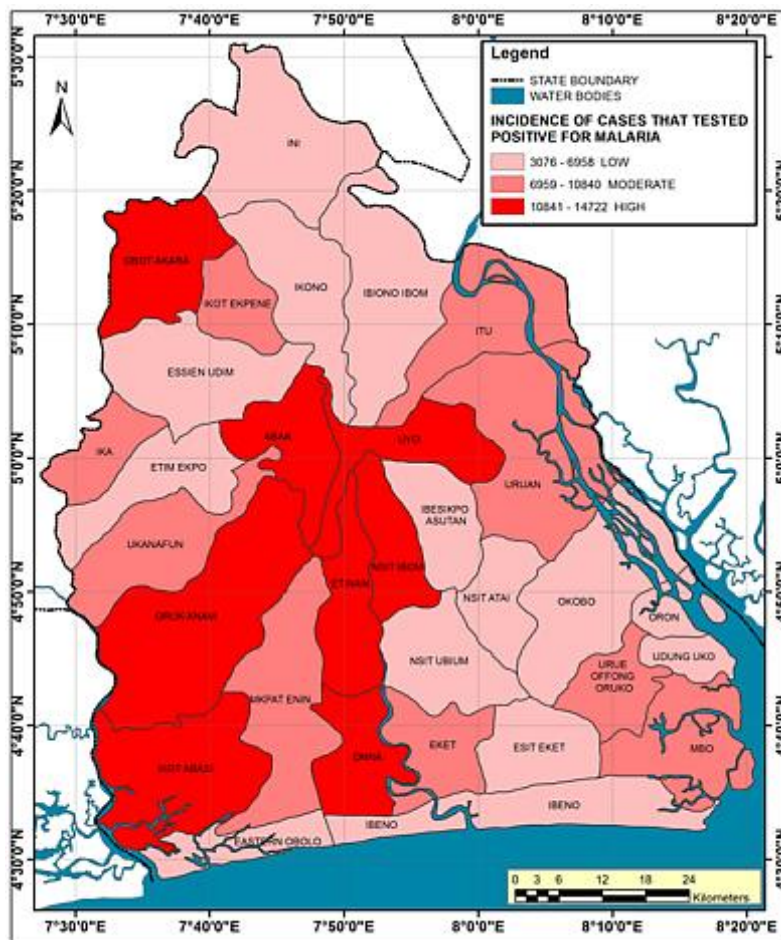
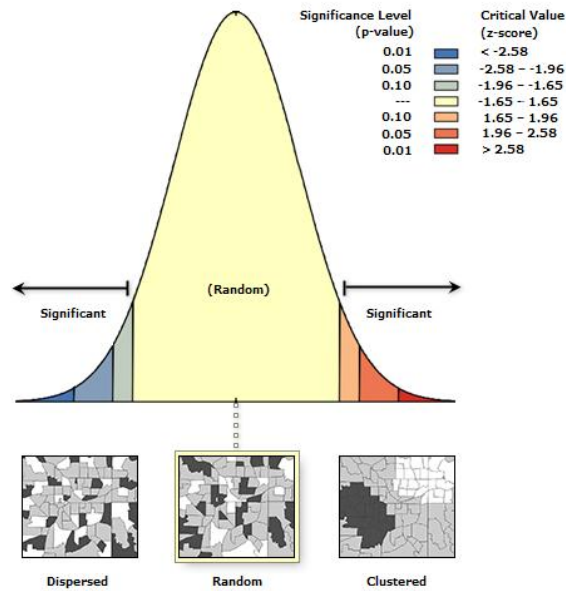


Fig. 9: Akwa Ibom State: Incidence of Cases that Tested Positive for Malaria by RDT  
 Source: Table 1

Using the Spatial statistics tool-Spatial Autocorrelation [Moran’s I] in ArcGIS 10 software package, this distribution pattern was analyzed to be random (Fig.10).



Given the z-score of 0.399600868933, the pattern is significantly random.

<b>Moran's Index:</b>	0.015830
<b>Expected Index:</b>	-0.033333
<b>Variance:</b>	0.015137
<b>z-score:</b>	0.399601
<b>p-value:</b>	0.689451

Fig. 10. Spatial Autocorrelation Report on the distribution of those/cases that tested positive for malaria by RDT

Furthermore, Fig.11 is a map showing the distribution of those/cases who had malaria presenting with fever. This map shows that the incidence of this category of malaria was high in Obot Akara, Ika, Abak, Uyo, Nsit Ibom, Etinan and Onna. Moderate in Ikot Ekpene, Essien Udim, Etim Ekpo, Ukanafun, Oruke Anam, Ikot Abasi, Mkpato Enin, Eket Mbo, Oron, Uruan, Itu and Ibesikpo Asutan LGAs. Low in the remaining LGAs. This distribution pattern was assessed to be clustered (Fig.12), using the Spatial statistics tool-Spatial Autocorrelation [Moran's I] in ArcGIS 10 software package.

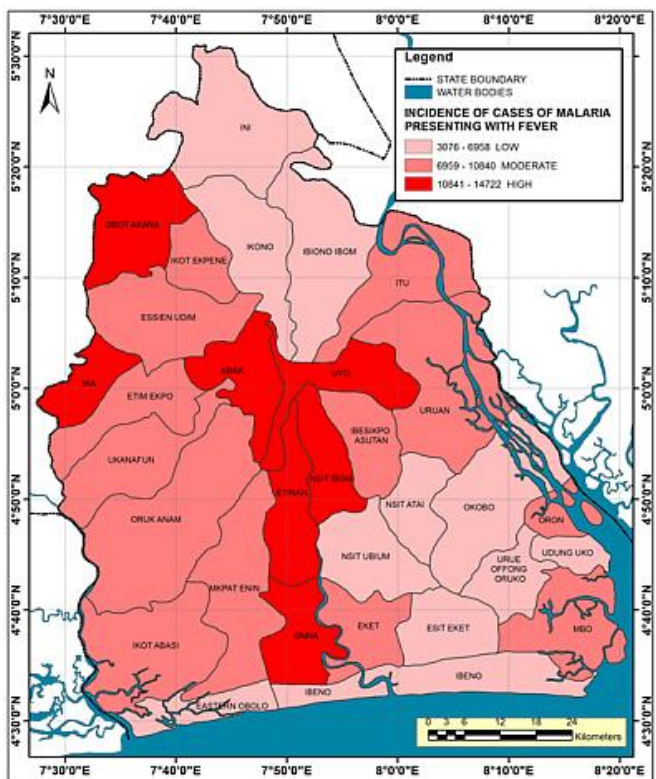
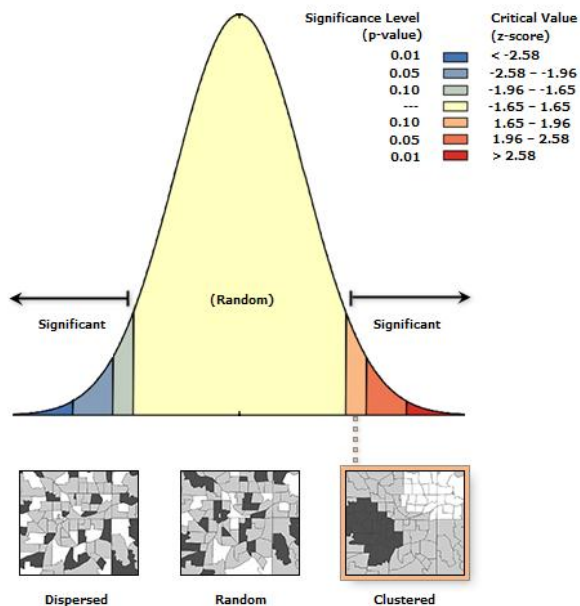


Fig.11. Akwa Ibom State: Distribution of those who had malaria presenting with fever [RDT]

Source: Table 1





Given the z-score of 1.80104840776, there is a less than 10% likelihood that this clustered pattern could be the result of random chance.

<b>Moran's Index:</b>	0.189204
<b>Expected Index:</b>	-0.033333
<b>Variance:</b>	0.015267
<b>z-score:</b>	1.801048
<b>p-value:</b>	0.071695

Fig. 12: Spatial Autocorrelation Report on those/cases who had malaria presenting with fever [RDT].

Also, Fig.13. reveals the distribution of reported cases of uncomplicated malaria in Akwa Ibom State in 2023. It is obvious from the map that the cases were high in few LGAs namely Obot Akara, Uyo, Etinan and Onna. It was moderate in Ikot Ekpene, Ika, Abak, Oruke Anam, Ikot Abasi, Mkpak Enin, Eket, Nsit Ibom and Mbo LGAs. It was low in majority of the LGAs numbering nineteen [19]. This pattern of distribution was assessed as random (Fig.14) using the Spatial statistics tool-Spatial Autocorrelation [Moran's I] in ArcGIS 10 software package

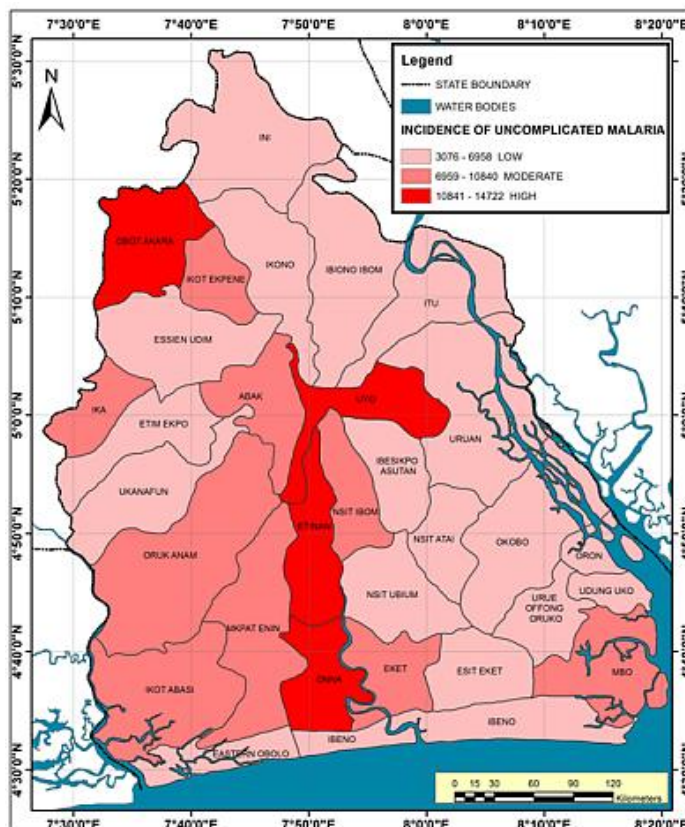
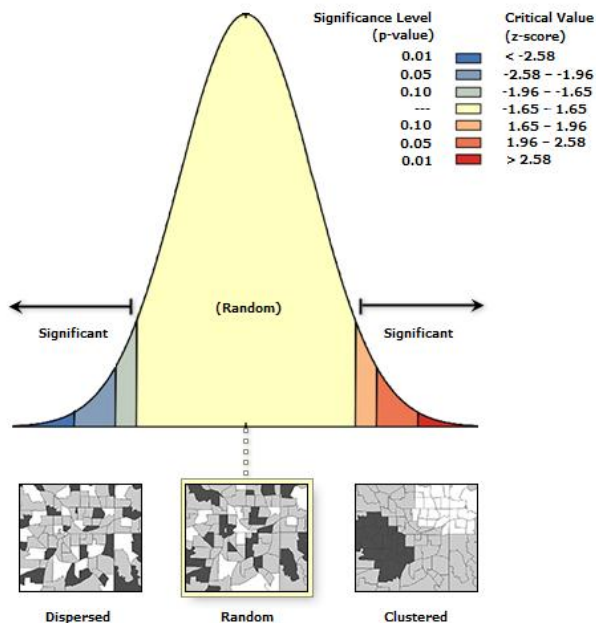


Fig.13. Akwa Ibom State: Distribution of reported cases of uncomplicated malaria  
Source: Table 1



Given the z-score of 0.360176922946, the pattern is significantly random.

<b>Moran's Index:</b>	0.011112
<b>Expected Index:</b>	-0.033333
<b>Variance:</b>	0.015227
<b>z-score:</b>	0.360177
<b>p-value:</b>	0.718715

Fig.14. Spatial Autocorrelation Report on the distribution pattern of uncomplicated malaria in Akwa Ibom State

### ***Testing the hypothesis on the distribution pattern of the incidence of malaria disease in Akwa Ibom State***

H<sub>0</sub>: The incidence of malaria disease in Akwa Ibom State is not evenly distributed.

#### ***Decision:***

The Z score of the Spatial Autocorrelation analyses in respect of the three categories of malaria disease were 0.399, 1.80 and 0.36. Since these figures were all within -1.96 and +1.96 limits, the null hypothesis cannot be rejected. This means that H<sub>0</sub> which states that, the incidence of malaria disease in Akwa Ibom State is not evenly distributed is accepted.

The implication of accepting the null hypothesis is that, the distribution patterns determined with moran's I in respect of the three categories of malaria incidence in the area were correct. Meaning that they were either random or clustered not even.

In this study, table 1 shows the different categories of malaria incidence reported in 2023. They included the following: Persons with Severe Malaria, Persons with Uncomplicated Malaria, Persons with clinically diagnosed Malaria, Persons with Malaria Presenting with Fever [RDT], Persons with Malaria Presenting with Fever [Microscopy], Persons Tested Positive for Malaria [RDT], Persons Tested Positive for Malaria [Microscopy]. It is obvious from table 1 that, the incidence of malaria disease was high and wide spread in the study area. This is partly because of the geographic location of the State in a malaria prone area. According to Sachs and Malaney (2002), the global pattern of malarial transmission suggests a disease centered in the tropics, in particular, the subtropical regions (which Akwa Ibom is part of).

In this region, changes in climatic parameters of temperature, rainfall and humidity as well as changes in land use and land cover have been shown to promote the breeding of mosquito and increase the prevalence of malaria (Adeboyejo *et al*, 2012; Krefis *et al*, 2011). Furthermore, this study also revealed the distribution pattern of the incidence of malaria to be random for the cases of persons that tested positive for malaria, cluster for cases of persons with malaria presenting with fever and random for uncomplicated malaria cases. These distribution patterns were mapped as shown in Fig. 9, 11 and 13 respectively. Moreover, of the 3 major categories of malaria in the study area, the cases of malaria presenting with fever was more in number than other categories. This can be partly attributed to its clustered distribution pattern. The issue of distribution pattern of the incidence of malaria disease or any other disease is often overlooked yet it is key to efforts that are aimed at eradicating or reducing incidence of disease in our environment. Random, cluster or disperse/even patterns have serious implications on a lot of things including but not limited to the ease of spread of the disease, allocation of resources, personnel, types of specific drugs and the cost of transportation required for any form of interventions adopted to eradicate and/or reduce the disease. For example if the high incidence areas/LGAs are clustered it will be faster and cheaper to move men and materials around than if such locations were dispersed or random.

## **5. Conclusion and Recommendations**

This study produced maps that have made it possible for the distribution pattern of the incidence of malaria disease to be discerned and/or visualized. This makes targeting those suffering from malaria disease for any programme of intervention very easy and cost-effective. With these maps and the GIS technology, it is possible to among other things determine precisely where the cases of malaria are prevalent, the state/conditions of infrastructure in such locations to mention just a few. This could in turn help the policy makers and all other stakeholders in combating this fundamental threat to well-being. Identifying where the sick are at a particular point in time is a gap in knowledge that must be consistently closed for us to make significant progress in malaria eradication/reduction.

Also the study has contributed by providing maps that show how the distribution pattern of the incidents of malaria was in 2023. Such maps are not currently available or in existence, yet we need them for planning and development as well as the distribution of resources and infrastructure required to alleviate/reduce the incidence of malaria.

Mapping of incidence of malaria or any other disease on yearly basis can easily reveal malaria endemic/prone regions as shown in this study. Such maps are veritable tools for determining and allocating resources needed to eradicate malaria or any other disease. Presently such decisions are most often based on personal/political considerations.

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