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MAPPING MALARIA CASE EVENT AND FACTORS OF VULNERABILITY TO MALARIA IN ILE-IFE, SOUTHWESTERN NIGERIA: USING GIS

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Abstract

The paper examines the spatial patterns of malaria case event, people's perception of transmission and prevention of malaria, and the factors of vulnerability to malaria in, Ile-Ife, Nigeria. Data on malaria reported cases (2004-2007) was obtained from Obafemi Awolowo University Teaching Hospital, Ile-Ife. Ile-Ife town comprising of two LGAs was stratified into the 21 existing administrative wards (neighbourhoods); in which 200 questionnaire were administered to households. Remote Sensing and Geographic Information System analytical operations employed with ArcGIS 9.2 include query, overlay among others. Results show there exists spatial variation in the occurrence of malaria with the highest cases recorded at Ilare1 (73), while Yekemi, Akarabata, Okewere1 and Modakeke2 have no reported case. Three mosquito prevention practices were reported, the use of mosquito repellent (30%), insecticide (20.5%) and bed-net (7.5%). Chi square analysis shows that significant relationship existed at $p<0.05$ between bed-net usage and income level (X^2 =13.520) and bed-net usage and education level (X^2 =1.012) Some observed environmental and behavioural factors make people vulnerable to malaria; for instance, 57.5% of households have temporary pools of water and water containers favourable for the breeding of mosquitoes around their dwellings. Also, 56.5% of the housing units surveyed do not have good drainages and 62.5% with no proper means of refuse disposal. The study concludes that the occurrence of malaria varies over space. Hence, malaria prevention efforts should take cognizance of spatial peculiarities as well as access to resources.

Key words: *Malaria case event; prevention; vulnerability; GIS; Nigeria.*

Introduction

The mapping of patterns in the spatial distribution of features has been of great significance in virtually all fields. The primary aim in the mapping process is to bring out hidden relationships among variables. This becomes important because geographical distribution of diseases reflects the social and environmental conditions that affect risk, susceptibility, social interaction and behaviors that facilitates occurrence, among these diseases is malaria. Malaria known as a communicable disease caused by protozoa parasites of the genus *Plasmodium* and transmitted to man by certain species of infected female anopheline mosquitoes (Oluwafemi, 2010). The challenge of malaria has been an issue of global concern, especially in developing and resource constrained countries of Africa, which is the continent with the highest occurrence of the disease (FMOH, 2001). Approximately, 70% of the total sub-Saharan Africa (SSA) population lives in areas dominated by malaria vectors (Trape *et al.*, 1987). Hence, Nigeria is one of the African countries with high prevalence rate of malaria (FMOH, 2001). However, spatio-temporal variations exist in the prevalence of the disease. This is because as at 2004, estimates showed that the malaria cases recorded in the South-South geo-political zone of the country was 461,718 cases with 590 deaths, 937,533 cases with 62 deaths in the South-West, 314,477 cases with 180 deaths in North- Central while 1,018,985 cases with 2,328 death in North-West (FMOH,2001).

Both behavioral and physical environment of people at risk of infection must be understood in any meaningful study of the disease because it provides the enabling environment for the disease vector to strive. The human ecology of disease, which is concerned with the ways human behavior in its cultural and socio-economic context interact with the environmental conditions to produce or prevent disease among susceptible people, occupies a central place in geographic approach to the study of etiology of disease in human society. It is therefore not surprising, that positive relationship has been found to exist between urbanization rate and status, and the prevalence of the disease affluence (Jamison *et al.*, 1993). Viewing the earth from space has become

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essential to comprehend the cumulative influence of human activities on its natural resource base. Over the past two decades, data from earth sensing satellites has become important in mapping the earth's features and studying environmental change. The use of multispectral reflectance data for mapping land cover variables vulnerable to malaria transmission has become an integral component of contemporary ecological studies (Bottomley, 1998). A growing number of Geographic Information System (GIS) studies as well as review articles Tanser *et al.,* (2000), indicate that Satellite Remote Sensing (SRS) and GIS are powerful tool for monitoring public health in various geographical locations. In the field of malaria control, Satellite remote sensing has become an important source of ecological data. In the field of epidemiology, however**,** this technology has rarely been applied**;** it is only slowly increasing in use. Remote sensing data are increasingly used for disease risk mapping, surveillance or monitoring, particularly of vector-borne diseases (Beck*,* 2000). Since the disease vectors have specific requirements regarding weather, climate, vegetation, soil and other land cover variables. The representation and analysis of maps of disease-occurrence data is a basic tool in the analysis of regional variation in public health. The development of methods for mapping disease occurrence has progressed considerably in the recent years. This growth in interest has led to a greater use of geographical or spatial statistical tools in the analysis of data both routinely collected for public health purposes and in the analysis of data found within ecological studies of disease relating to explanatory variables (Maheswaran and Craglia, 2004). One of the contemporary challenges today in mapping malaria occurrences and vulnerabilities is the paucity of information on both physical and socio-economic factors as well as preventive measures in developing countries where approximately 95% of the world's population suffering with malaria reside (FMOH, 2001)

In spite of the global and national fight against malaria and the huge expenditure to combat the disease, literature reveals that malaria still constitute a serious public health problem in Nigeria (FMOH,2005). This could be partly attributable to paucity of information on spatio-temporal variability of malaria case event, people's perception of the disease, preventive measures and identification of physical features associated with malaria occurrence. There have also been studies on the socio-economic burden and cost of various aspect of the disease (Ajala and Babatimehin, 2002). However, comprehensive empirical studies that identify the malaria case event locations in Nigeria are inadequate. Other studies on malaria disease in Nigeria have centered on specific interest of the medical professionals (Okogun, 2003). The need to investigate the existence of spatial patterns of malaria case event is to aid in planning interventions for the control of its burden and in the determination of underlying processes that may have given rise to its occurrence (Oliver *et al.,* 1992). Significantly, recent researches on malaria in Nigeria show that few studies were made and analysed using GIS and Remote Sensing. However, apart from Ifatimilehin's (2009) work on malaria risk mapping in Lokoja, North-Central Nigeria using space technologies, little empirical work has been done in this part of the world. Similarly, the dearth of information on malaria studies at micro scale poses a great problem in building a robust database which facilitates research in organizing, helping in surveillances, and in improving the links between academic research institutions.

Questions about geographical distribution of malaria cases and preventive measures have remained a daunting challenge both to policy makers and researchers at micro level in Nigeria largely because of dearth of data and where data are even available its quality cannot be guaranteed. Hence, this study analyses the spatial pattern of malaria case event, factors of vulnerability to malaria, people's perception and preventive measures in a traditional Nigerian city using geospatial technologies, with a view to take into cognizance access to resources towards eradicating malaria.

Study Area

Ile-Ife, comprising Ife Central and Ife East Local Government Area, Osun State, Nigeria constitutes the study area. The LGAs is located within latitude 7^o 31' and 7^o 35' North of equator and longitude 4^o 30'and 4 ^{o} 35'East of Greenwich Meridian. Ile-Ife city lies on the Southern flank of the western highlands of Nigeria consisting of 21 wards, with Ife central having 11 wards and Ife East with 10 wards (figure 1). Generally, Ile-Ife is an undulating terrain mainly in form of plains and valleys. Three major rivers Ogbe, Ilode and Esinmirin, which are tributaries to Opa River, drain the study area. Part of the floodplains within the study area is now occupied by residential buildings most especially Ogbe, Ilode and Esimirin. The built-up area of Ile-Ife is in fact growing quite fast towards the river channels and floodplains (Adediji and Oluwafemi 2007).

Climate

The study area falls under humid tropical rainforest climate, the area experiences marked wet and dry season associated with the tropical maritime (mT) and tropical continental (cT) air masses respectively. The wet season in the area is normally characterized by two maximal rainfalls with peaks occurring in July and September or October. The rainfall record of Ile-Ife between 1975-2000 indicates that annual rainfall varies from 923mm-2116mm with a mean of 1389.29mm, and temperature is generally high (Adediji,2002). The range of temperature during the dry season especially between December and April is between 21°C and 30°C.

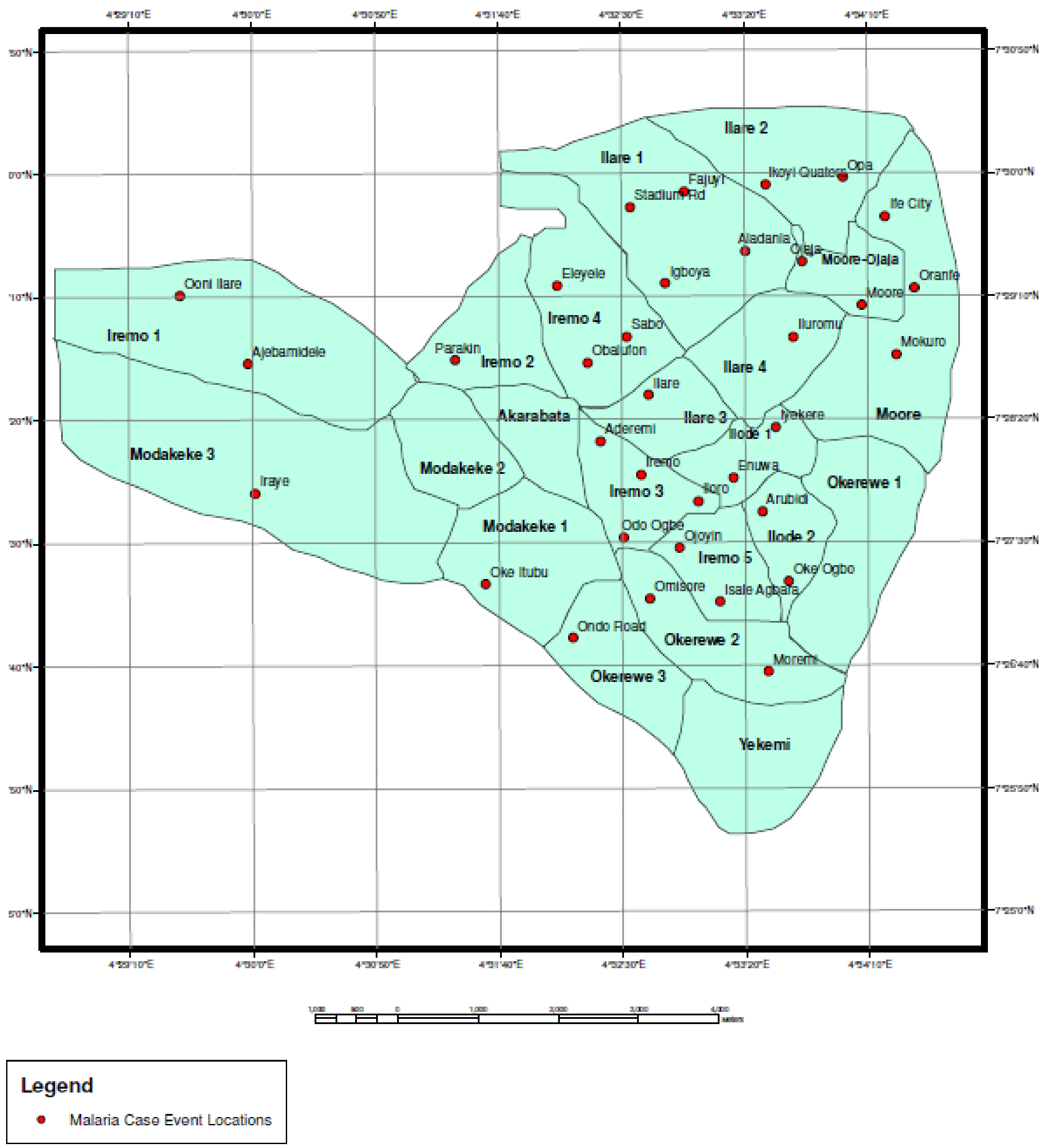

Figure 1 The study area, Ile-Ife.

Data Sources and Acquisition

Both primary and secondary data were used for the study. The primary data involved the use of Handheld Global Positioning System (GPS) receiver to obtain the geographic coordinates of Layout (Neighborhoods) where malaria cases were recorded according to data collected from a teaching hospital. The questionnaire administered on 200 randomly selected respondents in the study area served as the basic tool for collecting data from the primary source. The secondary source of data was the malaria reported cases (malaria case event data) within the study area. The data was collected from Obafemi Awolowo University Teaching Hospital Complex, Ile Ife for the duration of four years (2004-2007).

Data Collection Procedure

The malaria case event data collected from Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife was taken to the medical library to retrieve the case notes and information like residential address, age, sex, date and month of admission were all recorded. Its geographical reference usually the residential addresses of the cases, were used to determine malaria case event locations (Neighborhoods). The questionnaire sought three categories of information, these are: The first section deals with the socio-demographic characteristics of respondent which includes age, sex, marital status, occupation, education level and income level. The second section deals with information on environmental and behavioural factors of vulnerability to malaria which includes methods of waste disposal, method of sewage among others. The third section deals with information on mosquito-prevention practices. These included questions about what method(s) the household used in mosquito prevention and knowledge of mosquito breeding.

Data Preparation

A topographical map of the study area was used to locate and identify features on ground.

The geographical locations of the identified features on the ground were clearly identified. Thereafter, relevant layers (wards and malaria case event locations) were digitized and their various attribute tables created. Thereafter, the positional and attribute data of neighborhoods (malaria case event locations) where malaria was recorded for four consecutive years were structured in ArcGIS 9.3 environment and overlaid on the shapefiles already created. GIS spatial analytical functions used were overlying and querying.

Sampling

Multi-stage sampling was employed in this study. First, the study area was stratified into the 21 existing administrative wards. Thereafter cells of 1cm by 1cm were imposed on the administrative map of the study area so as to determine the number of questionnaires that will be administered in each ward out of the 200 earmarked for the entire study. The number of questionnaire administered in each ward was determined using the following formular:

Nqa = Ncw * Tnqa / Tnc where:

Nqa = number of questionnaires administered in each ward;

Ncw = number of cells in each ward;

Tnc = total number of cells in the study area;

Tnqa = total number of questionnaires administered in the study area (Oluwafemi, 2010).

Table 1 shows the distribution of questionnaires among the wards in the study area. In order to determine the households to be selected for interview, house listing was carried out and the list generated was used to randomly select the housing units. In each housing unit selected, household listing was carried out. This served as sample frame to randomly select the households interviewed. The head of selected households were interviewed.

Database Design

In the design of the database for this study, vector data model was adopted to depict the geometric representation of reality. The view of reality for this study includes: Malaria case event neighborhood, Ward, Local government area and other geographic entities. According to Kufoniyi (1997), spatial object is made up of two parts: (a) the geometric component of the object and (b) the attribute component. The two components were extracted for all objects in the geographic area of interest and structured in a GIS database.

Table 1 Computation and Distribution of Questionnaire in the Study Area

Name of Ward	Number of Cells	Computation	No of Questionnaire
Iremo 1	12	12*200/178 =13.5	13
Iremo 2	5	5*200/178 =5.6	6
Iremo 3	4	4*200/178 =4.5	5
Iremo 4	7	7*200/178 =7.9	8
Iremo 5	3	3*200/178 =3.4	3
Ilare 1	16	16*200/178 =17.9	18
Ilare 2	9	9*200/178 =10.1	10
Ilare 3	1	1*200/178 =1.1	1
Ilare 4	3	3*200/178 =3.4	3
Moore-Ojaja	2	2*200/178 =2.2	2
Akarabata	2	2*200/178 =2.2	2
Ilode 1	4	4*200/178 =4.5	5
Ilode 2	2	2*200/178 =2.2	2
Okerewe 1	9	9*200/178 =10.1	10
Okerewe 2	5	5*200/178 =5.6	6
Okerewe 3	11	11*200/178 =12.3	12
Moore	19	19*200/178 =21.3	21
Modakeke 1	4	4*200/178 =4.5	5
Modakeke 2	7	7*200/178 =7.8	8
Modakeke 3	38	38*200/178 =42.6	43
Yekemi	15	15*200/178 =16.8	17
TOTAL	**178**		**200**

Results and Discussion

Spatial patterns of malaria case event in Ile-Ife

Meades, *et al*., (1988), have observed that the disease experience of any community is not static but dynamic. Hence, the malaria profile of some studied societies has shown remarkable temporal variations. Table 2 summarizes spatial patterns of malaria case event (2004-2007) in the study area. Data from Obafemi Awolowo University Teaching hospital Complex show that there are 403 cases recorded in the studied years. The highest occurrence of malaria was reported in 2006 (112 cases) followed by 2005 (104 cases), 2007 (98 cases) while least occurrence was reported in 2004 (89 cases). Table 2 also show differences in total malaria reported cases for the four consecutive years in the study area based on administrative units. Thus, it is observed from Table 2 that spatial variation exists in the occurrence of malaria with the highest cases recorded at Ilare1 (73), Moore (55), Iremo (49) and Ilare (31). It is shown that numerous floodplains, gullies and drainage systems along these neighborhoods provide favourable breeding sites for the disease vector. Indeed, quite a number of houses are located along the floodplains and the river banks. Yekemi, Akarabata, Okewere1 and Modakeke 2 have no reported case this could also be attributable to internal communal clashes between Ile-Ife and Modakekes over Ife East Local Government headquarters in which virtually all the inhabitant of these neighborhoods vacated their homes. Figure 4 show the GIS-based map of spatial variation of malaria reported cases in different administrative units within the study area

Environmental and Behavioural Characteristics of Respondents

Studies have shown that man is intrinsically linked with his environment. Although, the physical environment provides the conducive breeding condition for the disease vector, the nature of social and economic activities determine the level of contact with the fly and therefore the intensity of bites received by an individual at any point in time. Table 3 shows the demographic characteristics of respondents while Table 4 and 5 contains summaries of both environmental and behavioural characteristics of respondents respectively. Table 4, indicated that more than half of the respondents were reported having temporary pools of water within their compounds with 57.5% value while households with no temporary pool of water in their compound was 42.5%. In this study, the people's proximity to floodplains, peri-domestic water vessels and stagnant water make them vulnerable to malaria. The proportions of households that have access to portable water among the respondents were 32.5% and highest proportion was recorded for respondents with no access to portable water with 67.5% in value. 38.5% of all households sampled reported clearing debris from drains and ditches in the compound with 61.5% recorded for households refused to clear debris from drains and ditches in their compounds. Also, 56.5% of the housing units surveyed do not have good drainages and 62.5% with no proper means of refuse disposal. Table 5, showed that 99% of the households cover their body and shielded themselves from mosquito bites. Also, 86% of the sampled respondents engaged in behavioral measures towards mosquitoes by closing their doors frequently in the morning or at night while 63.5% that is more than half of the sampled respondents within the study area had little or no information about mosquito breeding and development. However, individual are not knowledgeable about the vector borne parasite transmission but necessarily acting to prevent malaria.

Mosquito Prevention Practices in Ile-Ife

Given that humans desire to sleep peacefully and not be bitten, it is worth examining factors that determine the use of mosquito prevention practices. According to Macintyre *et al*.,(2002), the household mosquito prevention factors may include education and income level to test the validity of the assertion, bivariate analysis using Chi square was used. From the household survey, three mosquito prevention practices were reported, the use of mosquito repellent (30%), insecticide (20.5%) and bed-net (7.5%) (Table 6). Also, result from the bivariate analysis using chi-square showed that there is significant relationship between bed-nets usage and income level ($p<0.05$) (X^2 =13.520). However, result also indicated that there is significant relationship between bed-nets usage and education level among households ($p<0.05$) (X^2 =1.012). The study reveals that the higher the education and income level of the households, the higher the number of households using bed-nets (Tables 7 and 8).

Summary and Conclusions

The result revealed that occurrence of malaria cases varies over space, and that certain environmental and behavioural factors make people vulnerable to malaria. The findings of this study compared favourably with the findings of Ifatimilehin *et al.* (2006) where appreciable environmental differences reflected huge number of malaria cases around North Central Nigeria. The result of the study supports the knowledge that land cover variables like bare soil, cultivated lands, reservoir and light forest provide adequate sites for the disease vector in the study area. The basins characteristics of Ogbe, Ilode and Esinmirin favour the occurrence of the disease vector. The study indicates that adult cases of malaria were not adequately reported at Obafemi Awolowo University Teaching Hospital, Ile-Ife and huge cases were recorded between 0-18ages, this is partly attributable the high immunity of adults to malaria disease. However, the finding also indicate that high malaria cases were recorded in Ilare ward1 comprises of four neighborhoods namely, Stadium road, Fajuyi, Igboya and Aladanla and be attributed to poor drainage conditions in these areas. Low malaria cases were observed in Yekemi1,Akarabata, Okerewe 1and Modakeke 2. The result obtained showed clearly that households are using some form of protection. Also, education and income level of the households, serve as a prominent factor that determines mosquito prevention activity. However, the data do not suggest that individuals are knowledgeable about the vector borne parasite transmission but necessarily acting to prevent malaria. Consequently, people do not want to be bitten, irrespective of their knowledge of the transmission mechanism. This observation is similar to that of Okogun (2003), which concludes that knowledge of malaria was not a necessary prerequisite for mosquito-prevention practices. In view of the results discussed, it is therefore recommended that malaria prevention efforts should take cognizance of spatial peculiarities as well as access to resources.

Table 2 Trend in Malaria Occurrence (2004-2007)

SN.	Name of ward	REPORTED CASES OF MALARIA				
		2004	2005	2006	2007	Total
1.	Iremo 1	6	3	5	8	22
2.	Iremo 2	1	2	0	0	3
3.	Iremo 3	1	4	3	4	12
4.	Iremo 4	13	16	9	11	49
5.	Iremo 5	2	4	2	5	13
6.	Ilare 1	13	20	25	15	73
7.	Ilare 2	7	5	5	5	22
8.	Ilare 3	9	7	11	4	31
9.	Ilare 4	1	2	0	2	5
10.	Moore-Ojaja	2	1	4	1	8
11.	Akarabata	0	0	0	0	0
12.	Ilode 1	3	5	7	4	19
13.	Ilode 2	3	8	9	6	26
14.	Okerewe 1	0	0	0	0	0
15.	Okerewe 2	2	0	2	3	7
16.	Okerewe 3	5	6	9	7	27
17.	Moore	12	17	12	14	55
18.	Modakeke 1	4	2	6	4	16
19.	Modakeke 2	0	0	0	0	0
20.	Modakeke 3	5	2	3	5	15
21.	Yekemi	0	0	0	0	0
Total		89	104	112 98	403	403

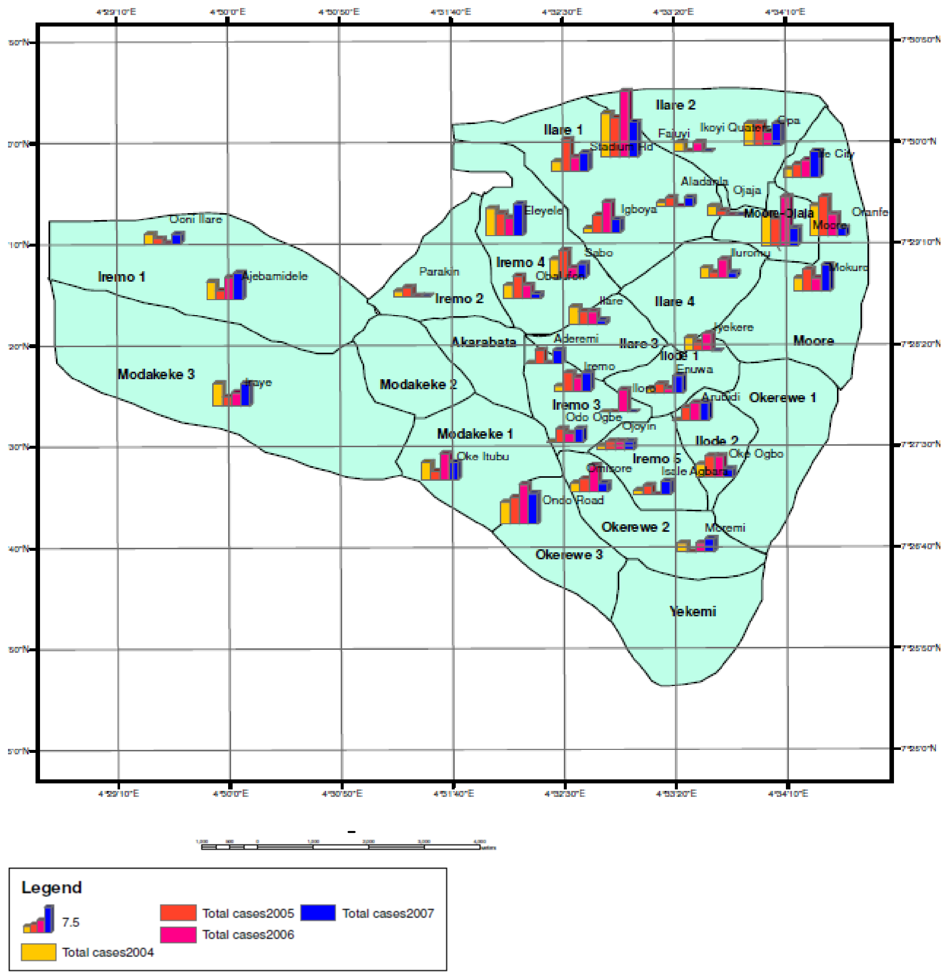

Figure 4 Total malaria cases from 2004-2009

Table 3 Demographic characteristics of the respondents (n=200)

Demographic characteristics	Response	
Age group	**Frequency**	**Percent**
25-34	32	16.0
35-44	75	37.5
45-54	68	34.0
55-64	25	12.5
Total	**200**	**100.0**
Sex		
Male	118	59.0
Female	82	41.0
Total	**200**	**100.0**
Marital Status		
Single	5	2.5
Married	191	95.5
Widowed	4	2.0
Divorce	0	0.0
Total	**200**	**100.0**
Occupation		
Student	4	2.0
Artisan	51	25.5
Civil service	69	34.5
Trader	54	27.0
Others	22	11.0
Total	**200**	**100.0**
Educational level		
Primary	53	26.5
Secondary	64	32.0
Non-Tertiary	55	27.5
Tertiary	26	13.0
Others	2	1.0
Total	**200**	**100.0**
Income		
Less than ₦10,000	2	1.0
₦11,000-₦20,000	2	1.0
₦21,000-₦30,000	8	4.0
₦31,000-₦40,000	54	27.0
₦41,000-#50,000	72	36.0
₦51,000 and above	62	31.0
Total	**200**	**100.0**

Table 4 Environmental Characteristics of Respondents

Temporary polls of water within the compound	Frequency	Percent
Yes	115	57.5
No	85	42.5
Total	**200**	**100.0**
Access to portable water		
Yes	65	32.5
No	135	67.5
Total	**200**	**100.0**
Clear debris from drains and ditches		
Yes	77	38.5
No	123	61.5
Total	**200**	**100.0**
Access to drainage system		
Yes	87	43.5
No	113	56.5
Total	**200**	**100.0**
Proper means of refuse disposal		
Yes	75	37.5
No	125	62.5
Total	**200**	**100.0**

Table 5 Behavioral characteristics of respondents

Household covers their bodies properly	Frequency	Percent
Yes	198	99
No	2	1
Total	**200**	**100.0**
Household close their doors frequently		
Yes	172	86.0
No	28	14.0
Total	**200**	**100.0**
Correct knowledge about mosquito breeding and development		
Yes	73	36.5
No	127	63.5
Total	**200**	**100.0**

Table 6 Mosquito Prevention Practices of Respondents

Household using insecticides treated net	Frequency	Percent
Yes	15	7.5
No	185	92.5
Total	**200**	**100.0**
Household using insecticides		
Yes	41	20.5
No	159	79.5
Total	**200**	**100.0**
Household using mosquito repellant		
Yes	60	30
No	140	70
Total	**200**	**100.0**

Table 7 Summary of Chi-Square Analysis

Items	Value	df	Asymp Sig(2-sided)
Pearson Chi-square	13.520(a)	4	.009
Likelihood Ratio	8.229	4	.081
Linear-by-Linear Association	5.480	1	.019

Table 8 Summary of Chi-Square Analysis

Items	Value	df	Asymp Sig(2-sided)
Pearson Chi-square	1.012(a)	5	.962
Likelihood Ratio	1.623	5	.898
Linear-by-Linear Association	.765	1	.382

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