Environmental Factors And Malaria Prevalence In Enugu Urban-Nigeria

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***Abstract*—This study examined the relationship between the natural environmental factors and malaria prevalence in Enugu Urban. Data were collected on natural environmental factors such as rainfall, humidity and temperature from 2005-2009. Number of children less than two years who were affected and those unaffected with malaria from 2005-2009 were also obtained. Tables were designed for collecting records on malaria cases among the age group from sixty four health facilities (hospitals, clinics, health centers, and health posts) within Enugu Urban and also for collecting records on the natural environmental factors of Enugu from State Ministry of Agriculture. Data collected were presented in tables, bar charts and line graphs. Hypothesis was tested using regression analysis. The results obtained showed that there is a significant relationship between environmental factors (temperature, humidity and rainfall) of Enugu Urban and malaria prevalence in the Urban. Though the natural environmental factors cannot be altered by man, the physical environment of Enugu Urban can be altered to reduce the effects of the natural factors on malaria prevalence. The study therefore recommends environmental manipulation and modification through vegetation clearing, proper waste management, and filling of potholes, ditches and health education of inhabitants, among others.**

Keywords:environmental factors, temperature, humidity, rainfall, malaria prevalence.

INTRODUCTION

Churchill [2] observed that malaria is a tropical disease caused by the presence of parasitic protozoa of the genus Plasmodium within the red blood cells and is transmitted by infected female mosquitoes of the genus Anopheles. Robert [8] in his own contribution said that malaria is a disease that causes chills, fever and sweating and is transmitted by the bite of female Anopheles mosquitoes, which have previously bitten infected person.

The history of malaria predates humanity, as this ancient disease evolved before human, Dibia [3]. Malaria is a widespread and potentially lethal infectious disease. It has afflicted people for much of human history, and has affected human settlement patterns. The prevention and treatment of the disease have been investigated in science and medicine for hundreds of years and since the discovery of the parasites which cause it, attention has focused on its biology. These studies have continued up to the present day, since no effective vaccine has yet been developed and many of the older anti – malaria drugs are losing effectiveness as the parasites evolves high levels of drug resistance. As malaria remains a major public health problem, causing deaths of millions in Africa, we are left with proper environmental management as an option to compliment the malaria treatments in order to reduce the burden of malaria in the present generation.

Science has proved that environmental factors influence distribution of diseases in human population. In order words environmental factors influences diseases distribution in any locality. These environmental factors may be natural or human-induced. The natural environmental factors are more of climatic factors such as temperature, humidity and rainfall, but the human-induced factors results from either omission or commission by man. According to Lawrence's, Immo and Timothy [4] several studies have shown that malaria infection like many other diseases is influenced by environmental factors, but Akabuike [1] remarked that the variation in magnitude, distribution and seasonal period of these natural factors determined the extent to which they contribute to malaria infection in different areas across the globe. Though malaria is a disease that affect all ages, according to Netsforlife (a partnership for malaria prevention in Africa) [6] young children under 2 years are most vulnerable to malaria because they have not built up immunity to the disease and without immunity the infection tends to be severe and more life-threatening. Therefore, to determine the prevalence of malaria in a particular place , this age group is preferred. This is because malaria can be easily identified in them due to their vulnerability.

In April 2000 African leaders from 44 malaria endemic countries met in Abuja, Nigeria for the African summit on malaria. One of the outcomes of the summit is advocacy on intervention through environmental management. They are of the view that environmental factors both natural and human-induced which favor breeding of the insect that transmits malaria should be identified and managed in every country. Enugu State including Enugu Urban has its own environmental characteristics both natural and human-induced that influence the disease distribution in the area. The extent these environmental factors influence malaria prevalence in Enugu Urban needs to be investigated for appropriate intervention.

THE STUDY AREA.

Enugu State is one of the states in southeastern Nigeria. Its capital is Enugu. The state was created in 1991 from the old Anambra State. Enugu state is located within latitude 60.00'N and 70.00'N and longitude 70.00'E and 70.45'E. The state is called the Coal City State because of the discovery of coal in a commercial quantity in Enugu Urban in 1909. Enugu was then the capital of East Central State of Nigeria. Some of the important towns in the State are Enugu Urban, Oji, Udi and Nsukka Urban. Figure 1 is the map of Enugu State showing Enugu Urban. The state shares borders with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west. Enugu State is made up of 17 local government areas. These include Igbo Eze North, Igbo Eze South, Udenu, Nssuka, Isi Uzo, UzoUwani, Igbo Etiti, Udi, Enugu East, Enugu North, Enugu South, Ezeagu, Nkanu West, Nkanu East, Oji-River, Awgu and Aninri local government areas.

Enugu Urban is also located within latitude 6.240N and 6.300N and longitude 7.270E and 7.320E. It is an hour's drive from Onitsha, one of the biggest commercial cities in Africa and 2 hours drive from Aba, another very large commercial city, both of which are trading centers in Nigeria.

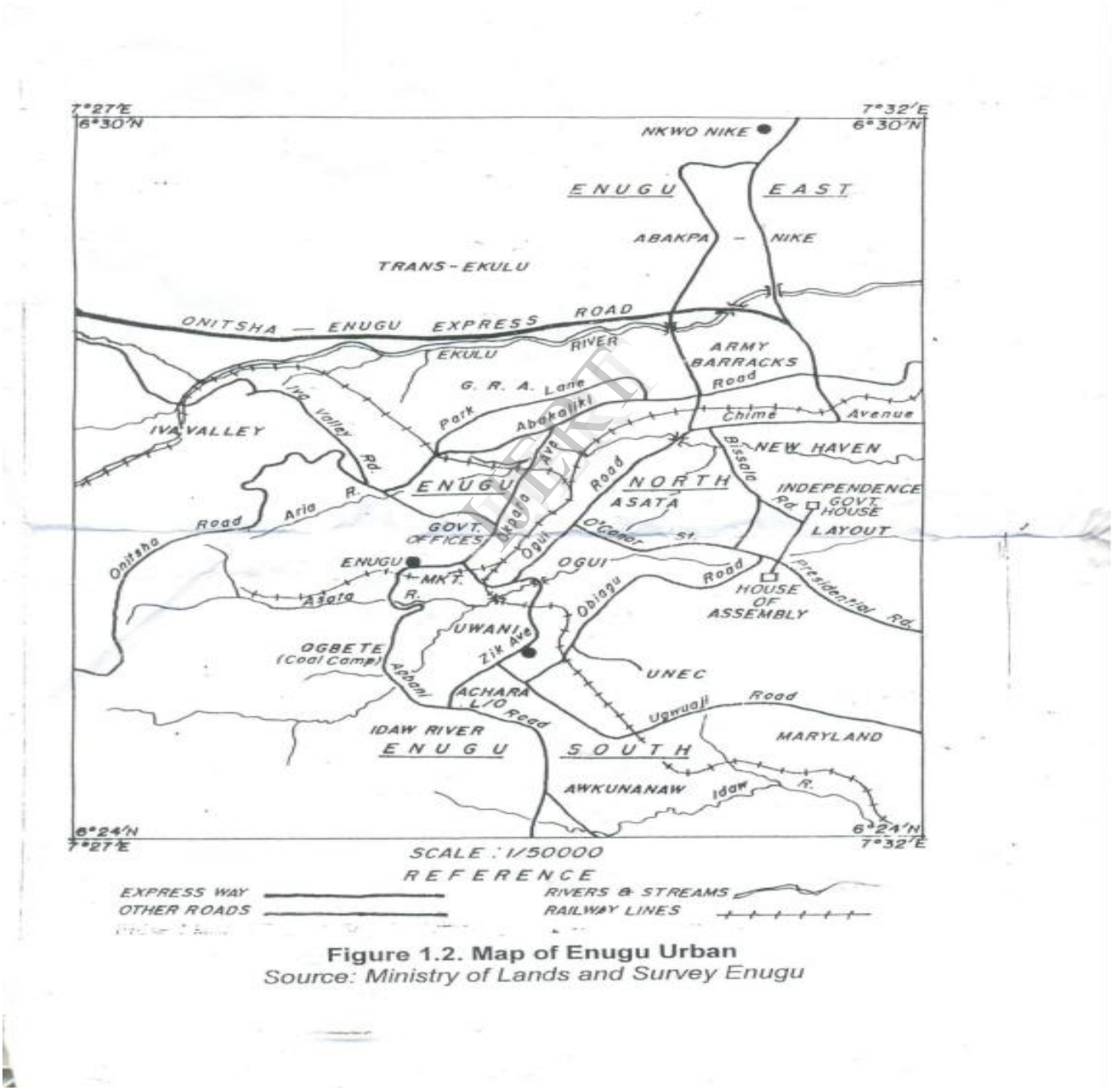


Figure 1.2. Map of Enugu Urban
Source: Ministry of Lands and Survey Enugu

Figure 1. Map of Enugu Urban

Source: Ministry of Lands and Survey, Enugu (2010)

Enugu Urban shares boundary with Igbo Etiti and Isi-Uzo Local Governments in the north, Udi local Governments in the west, Nkanu West Local Government in the south and part of Nkanu East Local Government Area in the east. Enugu Urban which is the study area is comprised of three local government areas; Enugu East, Enugu North and Enugu South Local Government Areas. There are 18 prominent residential areas in the Urban. These are Abakpa, Trans-Ekulu, Nike, GRA, Ogui, Asata, New Heaven, Obiagu, Ogbete, Iva valley, Independence Layout, Achara Layout, Ugwuaji, Maryland, February and records highest rainfalls of 37.7 cubic cm around June/July. The heavy rainfall and storm result in flooding. The turbulent runoff result in leaching, sheet erosion and eventually gullies (Akabuike, [1]). During the dry season the humidity is lower than in the rainy season. Temperature is most often high during the day and low during the night. This results in high evaporation rate during the day.

Enugu Urban is the educational, commercial, industrial and administrative base of Enugu State. The biggest market within the Urban is located within Enugu North Local Government Area; Ogbete Main Market. There are some other prominent markets such as Kenyeta market in Enugu South, Abakpa Market in Enugu East including New Market situated also in Enugu North. As the administrative center of the State, a reasonable percentage of the inhabitants are civil servants. They work in various Government establishments and offices.

CONCEPTUAL FRAMEWORK: SYSTEMS THEORY

This work is based on system theory. A system may be defined as structured set of objects or attributes, where these objects and attributes consist of components or blocks that has connections drawn between them, is interrelated with one another and operate together by way of some driving process, (Akabuike, [1]). The concept of the system is very useful in providing a means of understanding complex relationship between environmental factors that favour the breeding of mosquitoes and the longevity of malaria parasites and the transmission of malaria to man by the mosquitoes.

Awkanaw, Uwani, Agbani, and Coal Camp. Enugu Urban is the most developed urban area in Enugu state.

The study area falls within the humid tropical rain forest belt of Southeastern Nigeria. It has two seasons, the raining season and the dry season. The rainy season which is characterized by heavy thunderstorms lasts from April to October with the South Westerly moisture accompanied by air mass moving northwards into the city. The mean annual rainfall is about 0.16 cubic cm in

If the impact of environmental factors on malaria is to be understood, the entire cause-effect chain must be described and analyzed comprehensibly. The system approach seems to be the only approach which adequately reflects the complexity of the interrelationship between the environmental factors and mosquito and human population. The system not only explains the component of the various subsystems but also the interactions and processes between them, rather than focusing on each subsystem in isolation. The system approach can help to foster understanding of the relationship between environmental factors and malaria risks. Figure1. is a model showing the relationship between the environmental factors, mosquito system and human population.

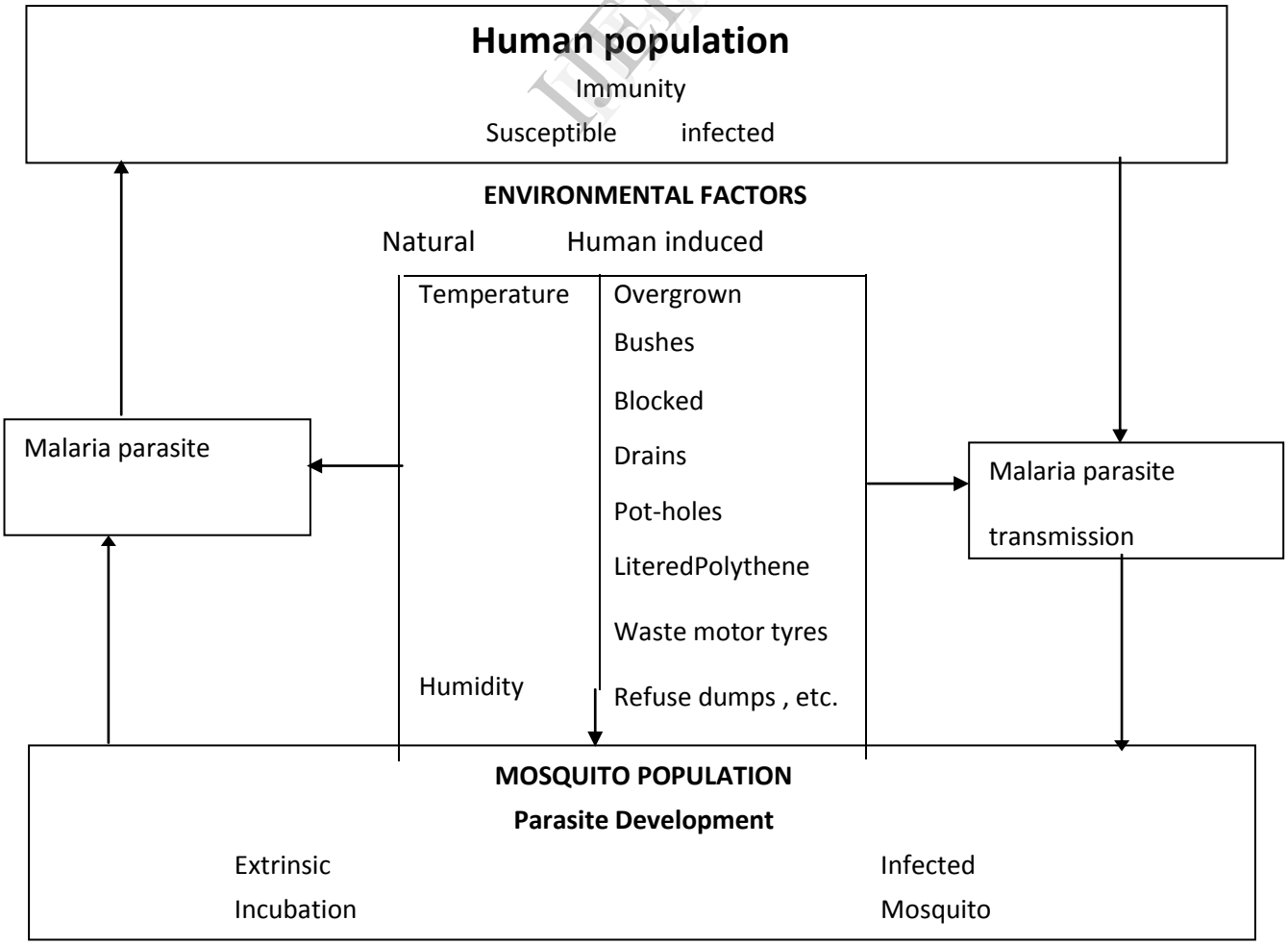


Figure 2: Malaria life cycle model (modified from Willem, Louis, Jan, Theo and Anthony 2005)

The model to assess the effect of environmental factors on malaria consists of several linked modules (i.e. subsystems): the environmental factors(natural and human-induced), the malaria system (divided into a human subsystem and a mosquito subsystem), and thus impact. The system is linked in a manner such that the output of one system serves as input of the next. The main environmental factors that have bearing on the malaria transmission and the mosquito population are temperature, humidity, precipitation and other human-induced factors such as overgrown bushes, blocked drains, pot holes and littered polythene materials .The interaction between the human sub-system and mosquito sub-system determines the transmission rates among the susceptible, the infected, and the immune. The impact system yields the rough estimate of the health impact of the environmental factors on malaria.

The life cycle of malaria parasite involves transmission both from mosquito to man and from man to mosquito, affected by the bite of infected female Anopheline mosquito. Inside the mosquito the extrinsic development of the parasites takes several days.

Rainfall may play a crucial role in malaria epidemiology because it provides the medium for the aquatic stage of the mosquito life cycle. Rain may prove beneficial to mosquito breeding if moderate, but, if excessive it may flush out the mosquito larvae. (Willem et. al. [7]). But it should be noted that even if the rain is moderate mosquito cannot breed without presence of other environmental factors such as potholes, bushes, blocked drains, littered polythene materials and other receptacles that can hold water after rain. This means that a well-drained area cannot support mosquito breeding even if the rain is moderate.

This research is to concentrate on the impact of Enugu Urban environmental factors: (temperature, rainfall, humidity) as a component of the integrated system of malaria life cycle on prevalence of malaria in the Urban.

RESEARCH METHOD

In respect of malaria cases and the secondary data were collected from 58 health facilities. In this work health facilities include hospitals, clinics, health center, health posts and laboratories. The meteorological data on environmental factors (temperature, humidity, and rainfall), were sourced from Enugu Agro-meteorological data of Ministry of Agriculture.

SUMMARY OF NO OF HEALTH FACILITIES (PUBLIC /PRIVATE) IN ENUGU URBAN. (EXCLUDING EYE AND DENTAL CLINICS)

LOCAL GOVERNMENTS	PUBIC HEALTH FACILITIES	PRIVATE HEALTH FACILITIES	TOTAL
ENUGU NORTH	21	84	105
ENUGU EAST	18	19	37
ENUGU SOUTH	7	28	35
TOTAL	46	13I	177

Source: Hospital Management Board Enugu (2009).

The sample size used was 64 determined through TARO YAMANE formula assuming the confidence level of 90% and unite of tolerable error of 10%.

Tables were designed for collection of data on cases of malaria and weather data of Enugu Urban. Out of 64 given to the sample health facilities only 58 of them were filled and returned and used for the analysis. Also similar tables were designed and were also used to collect data on monthly rainfall, humidity and temperature of Enugu Urban from Ministry of Agriculture Enugu. The data on cases of malaria and the environmental factors covered five years (2005 to 2009). Data collected in relation to cases of malaria and the values of temperature, humidity and rainfall for the period of study were presented in tables, bar charts and line graphs.

Multiple regression analysis was used for the work. The variable (Y) was regressed on variables X_1, X_2 and X_3 ,where X_1 is rainfall, X_2 is humidity and X_3 is temperature, with a view to estimating the values of (Xs) given the value of (Y). Regression equation, $Y = a + b_1x_1 + b_2x_2 + b_3 x_3 + e$

RESULTS

The table below shows the summary of number of children less than two years who had malaria in the area of study.

Table 1: Summary of number of children less than two years who had malaria between 2005 and 2009 as recorded in the health facilities

	No of children affected with malaria (under 2 years)					No of children unaffected (under 2 yrs)				
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
January	1334	1102	1218	1044 `	928	812	348	754	580	405
February	580	1044	1044	1044	1160	1276	290	232	522	686
March	638	812	1500	1218	1392	638	464	696	870	986
April	1508	1102	1566	1250	1760	812	982	406	928	1044
May	1856	1682	1334	1172	2088	812	928	406	928	1044
June	1798	1334	1708	2088	2014	1334	1392	638	812	1392
July	2146	1798	1782	2156	2204	986	696	1102	1160	1218
August	1914	1624	2146	1972	1856	406	1334	928	754	1044
Sept	1566	1740	1856	1450	1720	1218	1102	1276	928	1160
Oct	1334	1508	1740	1082	1056	589	1044	754	1276	986
Nov	1044	1682	754	1004	986	638	406	522	870	580
Dec	928	1044	586	638	910	754	928	464	69	812

Source: Clinical Records on Malaria from 64 health Facilities in Enugu Urban(2010).

From table 1 it can be observed that the month of July recorded the highest number of cases of malaria in 2005, 2006, 2008, and 2009 while in 2007 the highest case was recorded in the month of August. This implies that malaria infection threatens the life of less than 2years in Enugu Urban mostly between the months of July and August every year. The target population is shown below;

Table 2: Target population between 2005 and 2009 in respect of malaria cases among children less than 2 years in Enugu Urban.

YEARS MONTHS	2005	2006	2007	2008	2009
Jan	2146	1450	1972	1624	1333
FEB	1856	1334	1276	1566	1846
March	1276	1276	1701	2088	2378
April	2320	2084	1972	2178	2804
May	2668	2610	1740	2100	3132
June	3132	2726	2346	2900	3406
July	3132	2494	2884	3316	3422
August	2320	2958	3074	2726	2900
Sept	2784	2842	3132	2378	2880
Oct	1923	2552	2494	2358	2042
Nov	1682	2088	1276	1874	1566
December	1682	1972	1015	707	1722

Source: Curled from Clinical Records on Malaria from 64 Health Facilities in Enugu Urban (2010).

Below is a bar chart that shows cases of malaria from 2005 to 2009

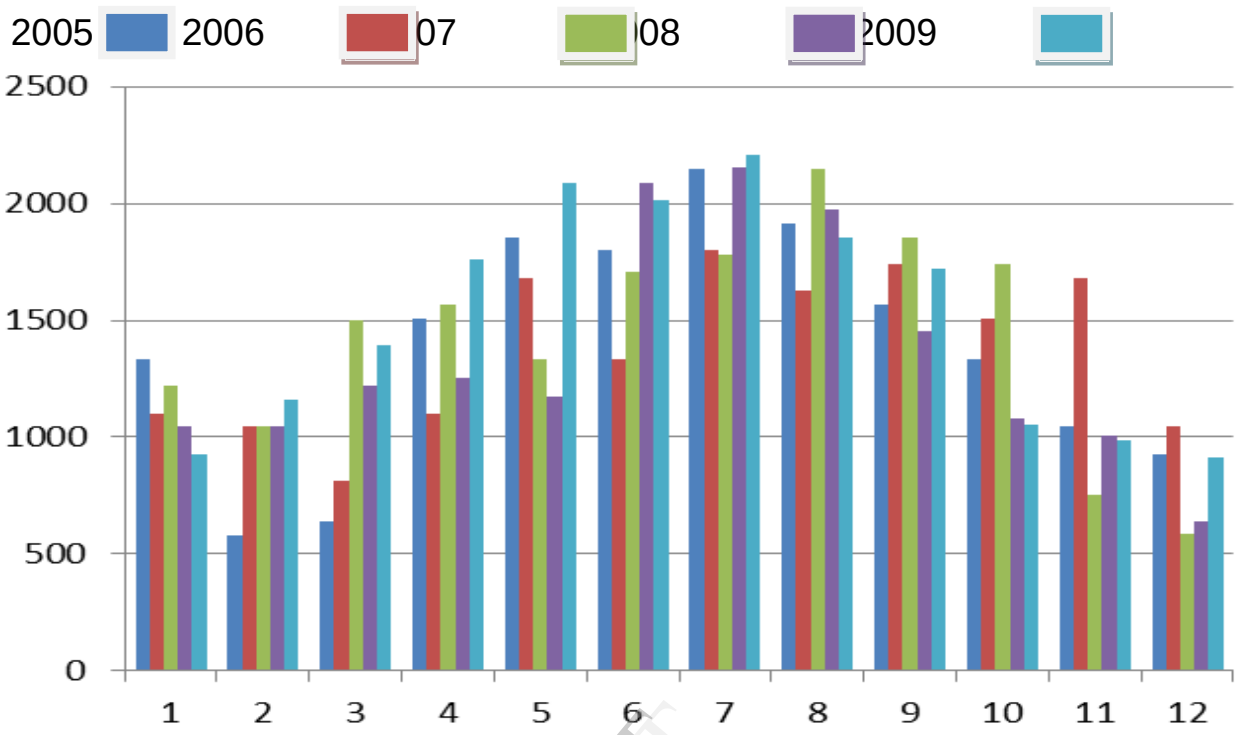


Figure 3: Bar chart of cases of malaria between 2005 and 2009.

The legend shown in the chart indicates that 2005 is blue, 2006 is red, 2007 is green, and 2008 is purple while 2009 is sky blue. The result shows that the cases are highest between June, July and August each year. Also figure 4 shows cases of malaria in 2005 from January to December

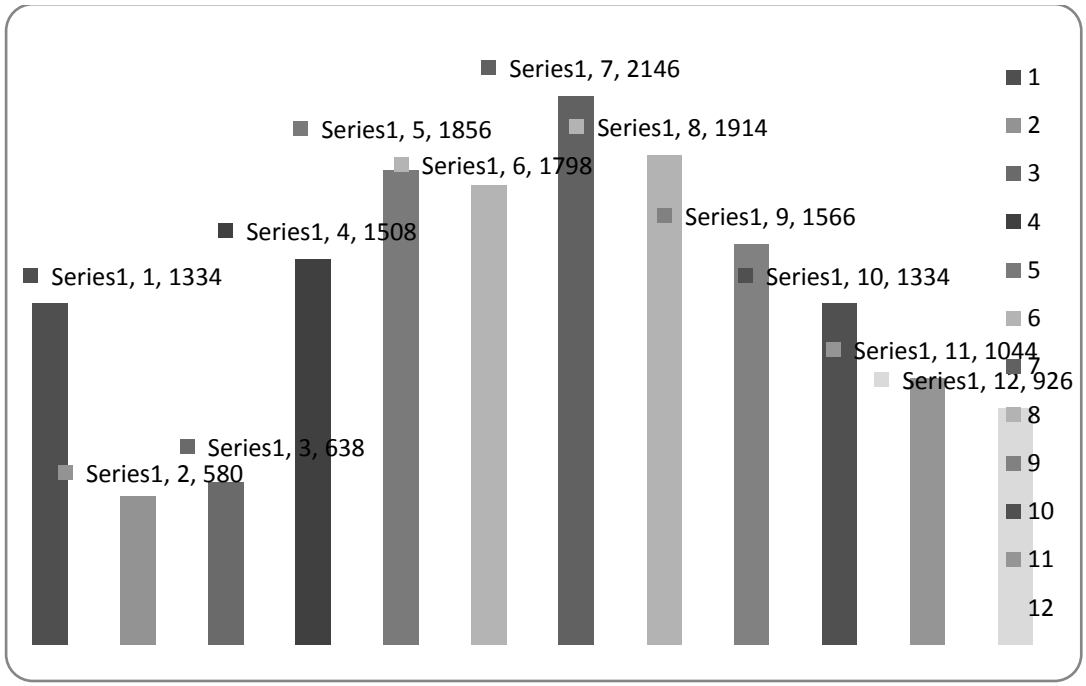


Figure 4:Bar chart of cases of malaria in 2005 from January to December.

The bar chart in figure 4 shows that in 2005, the cases of malaria recorded is highest in the month of July, but lowest in month of February. From the research it could be noted that in 2005 the month of August has the highest prevalence with the lowest in February (see table 3).

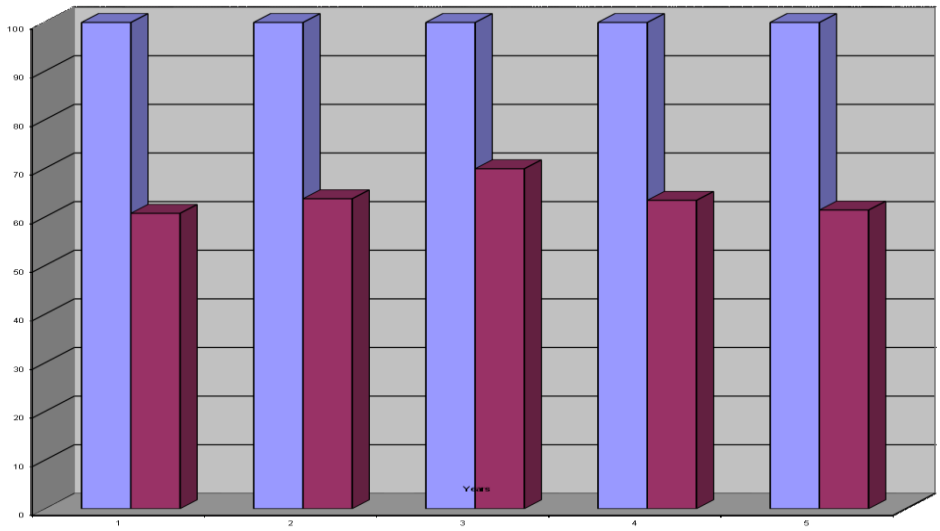
Table 3: Prevalence Rate of Malaria between 2005 and 2009.

	YEARS				
Months	2005	2006	2007	2008	2009
1	62	76	62	64	70
2	31	78	82	67	63
3	50	64	88	58	59
4	65	53	79	57	63
5	70	64	77	55	67
6	57	49	73	72	59
7	69	72	62	65	64
8	83	55	70	72	64
9	56	61	59	61	60
10	69	59	70	46	52
11	62	81	59	54	63
12	55	53	58	90	53

Source: Authors Computation (2010).

In the year 2006, the highest prevalence is recorded in the month of November but lowest in the month of June. In the year 2007 the month of March has the highest prevalence while the lowest was recorded in the month of December. In the same manner the month of December and January recoded highest prevalence in the year 2008 and 2009 respectively with the lowest in the month of October in each of the year.

From the findings, it was proved that between 2005 and 2009, the year 2007 recorded the highest prevalence with a percentage of 69.92%. The year 2005 recorded the lowest with a percentage of 60.75%. In 2006 it was 63.75%, in 2008 and 2009 it was 63.42% and 61.42% respectively.



- Year
- Percent Prevalence

s/no	rainfall	rel humidity	Temp	prev mal	s/no	rainfall	Rel. humidity	temp	prev mal
1	1000	86.3	25.4	62	31	258.81	78.5	24.1	62
2	0	69.1	26.1	31	32	364.13	77.9	24.4	70
3	15.5	81.5	25.3	50	33	283.8	77.4	25.3	59
4	84.19	79.1	24.1	65	34	204.47	76.6	25.8	70
5	198	78.1	24.1	70	35	37.13	78.4	25.8	59
6	220.81	76.7	25.1	57	36	2.6	75.7	25.1	58
7	300.81	78.5	24.1	69	37	0	69	25.1	64
8	364.13	77.9	24.4	83	38	0	91.7	26.8	67
9	280	77.4	25.3	56	39	20.1	82.7	27	58
10	200.1	76.6	25.8	69	40	80.15	79.5	25.2	57
11	60.5	78.4	25.8	62	41	331.67	84.1	26	55
12	14.13	75.4	26	55	42	549.52	85.9	25.8	72
13	0	68.4	25.1	76	43	655.47	84.1	25	65
14	0	90.4	25.2	78	44	95.13	82.8	24.5	72
15	18.15	82.6	24.7	64	45	140.22	81.5	25	61
16	80.15	79.1	24.2	53	46	49.61	83.4	26.4	46
17	333.32	80.24	26	64	47	5.87	81.1	26	54
18	549.6	85.9	25	49	48	20.87	86	26.1	90
19	653.4	86.5	24	72	49	66.4	85.5	25.4	70
20	95.48	82.8	25.5	55	50	0.6	81.3	26.9	63
21	150.33	81.4	25.1	61	51	36.4	86.2	26.3	59
22	49.12	23.6	26.1	59	52	78.4	80.5	25.8	63
23	5.87	81.1	26	81	53	156.2	74.8	26.5	67
24	21.12	86	26.3	53	54	216.2	80.3	25.8	59
25	0	86.3	24.3	62	55	321.07	77.7	24.9	64
26	0	69.1	25.8	82	56	80.01	18.2	25.6	64
27	16.5	81.5	25.8	88	57	87.7	79.4	25.8	60
28	84.19	79.1	24.1	79	58	51.8	80.1	26.5	52
29	198.83	78.1	24.3	77	59	4.9	81.1	26.4	63
30	205.81	76.7	24.8	73	60	2.6	77.9	26.6	53

Source: Ministry of Agriculture Enugu.

There is a great variation in rainfall recorded between January and December each year. Rainfall reaches its peak between the months of June and August each year with the lowest in the early and later part of the year. For humidity and temperature, there are not many variations in the data from January to December each year.

SUMMARY OF FINDINGS

1. Malaria cases are more common and reach its peak in the months of June, July and August each year between 2005 and 2009 in Enugu Urban.
2. Malaria transmission is seasonal. Cases are more in rainy season than dry season.
3. Number of children less than 2 years affected with malaria each month between 2005 and 2009 is always higher than number unaffected in Enugu Urban.
4. Between 2005 and 2009, the highest prevalence was recorded in the year 2007 with a percentage of 69.92% while percentage prevalence is lowest in 2005 with 60.75%.
5. Between 2005 and 2009 malaria prevalence rises from 2005 and reaches peak in 2007, but in 2008, it started to decline.
6. For each of the year, there is a great variation in amount of rainfall from January to December but for humidity and temperature, there is not much variation in a year.

7. Rainfall reaches its peak in the month of June, July and August each year between 2005 and 2009 Enugu Urban.

8. The average rainfall, humidity and temperature for the period of study are 157 (mm), 78% and 25oC respectively.

9. There is a weak positive correlation between rainfall, humidity and malaria prevalence.

10. Temperature has a strong negative correlation with prevalence of malaria.

11. Rainfall, humidity and temperature all together could not predict prevalence of malaria in Enugu Urban.

12. Temperature contributes to malaria prevalence most among the variables involved.

RECOMMENDATIONS

It has been proved that environmental factors such as rainfall, humidity and temperature cannot be controlled by man since they are natural phenomenon. As earlier noted in the research, rainfall for instance contributes to mosquito breeding only if there are human induced environmental factors such as pot-holes, blocked drainages, and receptacles that can hold water after rain. Since the natural factors cannot be changed or controlled by man, the physical environment of Enugu Urban can be manipulated or modified to eliminate the breeding sites of mosquito. Recommendations are therefore focused on legislation, environmental manipulation, environmental modification, and health education of the inhabitants of Enugu Urban.

1. Legislation on empty water sachets and receptacles that can hold water after rain. The legislation should be centered on the storage, movement and disposal of this receptacles and empty water sachets. Hawkers are to move about with small waste bins to collect immediately empty water sachets into the bin and later disposed properly or sent for recycling. Other receptacles such as empty cocoanut shells, empty tins, broken plastic containers e.t.c should not be allowed to be littered in the environment.
2. Filling of potholes, low lying areas and ditches to remove potential mosquito breeding sites in Enugu urban. These are particularly important if situated close to human habitation.
3. Proper solid waste management is recommended. Refuse should not be allowed to dump for a long time before taken to final disposal sites.
4. Attention should be given to proper refuse management as an environmental management approach to malaria control and not only as a way of beatifying the streets.
5. Since the environment support mosquito breeding mostly in rainy season a special campaign for clean environment in respect of proper waste disposed, clearing of bushed, filling of potholes etc should be organized to alert the inhabitants of Enugu urban of the danger ahead. Jingles in televisions and radios are also necessary.
6. Vegetation clearing is also recommended to remove resting places and outdoor sheltering of mosquito. Also clearing of overgrown bushes close to residents increase water evaporation and thereby contribute to a reduction in breeding sites of mosquito.
7. Introduction of larvivorus fishes to ponds and swimming pools as predators of mosquito's larvae using edible fish can turn environmental management into a more profitable method of malaria control. For example Gambeson species.
8. Introduction of larvicides into non-drinkable water bodies both large and small to kill mosquito larvae is necessary.
9. The Enugu State Waste Management Agency should rise to this challenge of waste management in other to ensure a drastic reduction in malaria prevalence in Enugu urban.
10. Mosquito scouts should also be trained to join had with other professional bodies like environmental managers and environmental health officers to ensure good planning, organizations and motioning of activities for the modification and manipulation of environment with a view to preventing or minimizing mosquito propagation.
11. Other methods that may be employed to reduce malaria prevalence in Enugu Urban include screening of houses, sleeping under mosquito nets, and public education.

CONCLUSION

This research work has considered environmental factors that affect malaria prevalence in Enugu Urban. The research work has made findings on the environmental factors that contributed most to malaria transmission. Among the environmental factors measured, rainfall was identified to have contributed most to malaria case while temperature has a strong relationship with prevalence of malaria in Enugu Urban within the period of study. The research also proved that rainfall and human- induced environmental factors work hand in hand to affect malaria cases and prevalence in the Urban Area. However, this is not in isolation to other factors such as humidity and temperature. The findings also revealed that there is high prevalence of malaria among children less than two years in Enugu Urban as at 2009 which recorded 61.42%. Finally there is a significant relationship between the environmental factors in Enugu urban and prevalence of malaria in the Urban.

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