A STATISTICAL STUDY OF THE INCIDENCE AND MORTALITY RATE OF REPORTED CASES OF MALARIA IN IMO STATE, NIGERIA.

(A Case Study of Privately Owned Hospitals in Imo State Nigeria)

By

Jude OPARA

Department of Statistics, Imo State University, Owerri, Nigeria

-

Anderson Chukwukailo NWOBI

Department of Statistics, Abia State Polytechnic, Aba, Nigeria

-

Andrew I. IHEAGWARA

Department of Statistics, Imo State University, Owerri, Nigeria

Abstract: This study is on the incidence and mortality rate of reported cases of malaria in Imo state, Nigeria. The statistical software package known as "MINITAB version 16.0" was used for the analysis. This study centred on only privately owned hospitals in Imo State, Nigeria. The data were collected from two randomly selected private hospitals in Imo state. The hospitals are St. Joseph Hospital, Eziala Enyiogugu Aboh Mbaise Local Government Area of Imo State; and Hossana Hospital Logara, Ngor Okpala Local Government Area (L.G.A) of Imo State. The two selected hospitals represent a true population of the study. The sampling technique adopted is the simple random sampling by using the table of random numbers. The findings of this study include that: the mean incidence of malaria does not differ significantly across the years; the mean incidence of malaria in Imo State differs significantly across the age groups; the mean malaria mortality in Imo State Nigeria is equal across the years; the mean of malaria mortality, in Imo State, differs significantly across the age groups; the incidence of malaria, in Imo State Nigeria, is not equal between males and females. Malaria mortality is not equal between males and females in Imo State. The proportion of the incidence of malaria in, Imo State Nigeria is not equal across age groups. The proportion of malaria mortality, in Imo State, is not equal across age groups.

Keywords: Malaria, Mortality Rate, ANOVA, Runs Tests, Equality tests, Bartletts Test, and Shapiro Francia's Test.

INTRODUCTION

Malaria is a mosquito borne disease caused by a parasite called plasmodium (Henderson, 1999). This plasmodium has four species which include plasmodium falciparum, plasmodium vivax, and plasmodium ovale and plasmodium malariae. Malaria parasite is transmitted from one person to another through the bite of a female Anopheles Mosquito which require blood to nurture her eggs. When Malaria parasites enter the blood stream of a person, they infect and destroy the red blood cells. The destruction of these essential cells leads to fever and flu-like symptoms such as chills, headache, muscle aches, tiredness, nausea, vomiting and diarrhea. Malaria, when not treated, can lead to coma and death.

Globally, Malaria is increasingly becoming a disease of serious concern to everybody. This is because day by day, the impact of Malaria in human existence, the world over, becomes more ravaging and damaging as a result of high morbidity and mortality experienced in different parts of the globe especially the developing countries of which Nigeria is one.

Malaria parasite has been with man since the dawn of time. Hippocrates, a physician born in ancient Greece, today regarded as the "father of medicine" was the first to describe the manifestation of the disease.

The association with stagnant water (breeding grounds for the Anopheles Mosquito) led the Romans to begin drainage program, the first intervention against Malaria. The first recorded treatment of Malaria dates back to 1600, when the bitter bark of cinchona tree in Peru was used by the native Indians. Not until 1889 was the protozoa (single celled parasite) cause of Malaria discovered by Alphonse Laveran and only in 1987 was the Anopheles Mosquito demonstrated to be the vector for the disease by Ronald Ross. The discovery of Ronald Ross was followed by a series of important works which not only enlarged the understanding of Malaria but also supplied useful knowledge in the combat against Malaria and prevention of Malaria. Despite initial success, there was a complete failure to eradicate Malaria in many countries (Mills et al; 2008).

According to World Health Organization (WHO), Center for Disease Control and Prevention (CDCP), Roll Back Malaria Partnership (RBM), (2010), 3.3 billion people-half the world's population- are at risk of Malaria; one million people die each year from Malaria; every 30 seconds a child dies from Malaria. Also, in Africa, 91% of all Malaria death cases occur in Sub- Sahara Africa; 1 in 5 childhood deaths are caused by Malaria; 10, 000 pregnant women and 200, 000 infants die from Malaria every year.

Further more, one in ten infant's deaths and 25% of deaths in children below the age of four years is attributable to Malaria in Africa (Ofovwe and Erejie, 2001 and Ezedinachi et al, 1998). The country records about 1858 deaths per 100, 000 population from Malaria and Malaria is responsible for 60% of patients visits to health facilities and also about 30% and 11% of childhood and adult deaths, respectively (N M C P, 2011).

Malaria accounts for an estimated 2 to 3 million deaths annually and is also responsible for untold morbidity in approximately 300 to 500 million people annually. Susceptible groups are children and adults who have host or never acquired immunity (Smith et al, 2002). Malaria is said to kill about one African (whether child or adult) every 15 secs and roughly 300, 000 Nigerian children annually (Salako, 2002).

Malaria is responsible for over 10% of the overall African disease burden. Children under five years of age (22% of the population) and pregnant women (20% of the population) are the most vulnerable to Malaria disease (Guillet et al, 2001). Nigeria is known for a high prevalence of malaria (Federal Ministry of Health, 2001 and Onwujekwe et al, 2000) and it is a leading cause of morbidity and mortality in the country (Federal Ministry of Health, 2001). Available records show that at least 50% of the population of Nigeria suffers from at least one episode of Malaria each year and Malaria accounts for over 45% of all out-patient visits (Federal Ministry of Health, 2001 and Ejezie et al, 1991).

It was reported that malaria prevalence (notified cases) in 2000 was about 2.4 million and responsible for an estimated average annual reduction of 1.3% in economic growth for the countries with the highest burden, Nigeria inclusive (Federal Ministry of Health, 2001 and Onwujekwe et al, 2000). Therefore, it imposes a great burden on the country in terms of pains and trauma suffered by its victims as well as loss in output and cost of treatments (Onwujekwe et al, 2004).

STATEMENT OF PROBLEM

Government, organizations and individuals all over the globe have made frantic efforts, not only to prevent, but also to eradicate Malaria since its discovery. These efforts can be seen in the introduction of treated bed nets and in the works of WHO, CDCP, RBM, National Malaria Control Programme (NMCP) and many other health organizations.

Despite all these wars waged against Malaria and even though so many research has been done on Malaria over the years past, its incidence and mortality rate increase on daily basis in many developing countries, of which Nigeria is one. This shows that there is a basic lack of high-quality epidemiological data on the incidence and mortality rate of Malaria in many endemic areas.

This study will serve as an eye opener to the populace of Imo State of Nigeria as it is geared towards giving a detailed overview of incidence and mortality rate of malaria from the available figures.

AIMS AND OBJECTIVES

The aims and objectives of this study include:

a.   To showcase the true figure in the incidence and mortality rate of Malaria in Imo State, Nigeria.

b.   To ascertain if there is the presence of trend in the incidence and mortality rate of Malaria, and to know then the nature of the trend.

c.   To check the mortality rate of the number of people that died from Malaria against the reported cases of Malaria.

d.   To know whether the incidence and mortality rate of Malaria are dependent on sex, age and year.

SCOPE AND LIMITATIONS OF STUDY

This research work is centred on the incidence and mortality rate of reported cases of Malaria in Imo State, Nigeria from 2000 to 2012. It is limited to the data on the monthly reported cases of Malaria patients treated in two Private owned hospitals in Imo State. The findings of this study are limited to the methods or techniques used in the study.

RELEVANCE OF STUDY

This research work will, to a great extent, be of importance in the following ways:

a.   It will enlighten and sensitize the public more on the incidence and mortality rate of Malaria in the State.

b.   Future researchers on malaria and other disease can be guided by this work as template to a more detailed investigation into the incidence and prevalence of Malaria and other diseases.

c.   Health planners in the State may benefit from the result of this work as it will attempt to give a true picture of the incidence and mortality rate of Malaria in the State.

d.   It will serve to further encourage the use of analytical techniques in finding facts about other diseases that plaque mankind.

LITERATURE REVIEW

Many researches have been done in the past regarding incidence and mortality in Malaria. The need to review some of these previous works and other related topics is necessary as it will add test to this study.

Durueke (2005) carried out a research on the incidence, management and bionomic of malaria in children under 5 years of age in parts of Isiala Mbano L.G.A, Imo State, from November 2004 to August 2005. Using a chi-square test for proportion, the result revealed that the incidence of malaria in the studied area was inversely proportional to the socio-economic levels of the areas under study. Also, the incidence of malaria increased with decrease in socio-economic level and decreased with improvement in standard of living.

Gerritsen et al (2008) carried out an analysis on malaria incidence in Limpopo Province South Africa from 1998 to 2007, using chi-square test of independence and time series analysis, the result showed that out of 58768 cases of malaria reported including 628 deaths, the mean incidence of malaria was 124.5 per 100, 000 person and the mean mortality rate was 1.1% per season. Also, there was a decreasing trend in the incidence over time, and the mean incidence in males was higher than in females. Finally, the result revealed that incidence in malaria peaked at the age of 35 to 39 years, decreased with age from 40 years and is lowest in 0 – 4 years old. The Fixed Case Fatality Rate (CFR) increased with increasing age.

Ayeni (2011) conducted a research titled "Malaria Morbidity in Akure South West, Nigeria: A temporal observation in climate change scenario, from 2000 to 2008". Applying the method of time series analysis, the result revealed that malaria morbidity was generally low before 2004 and that the reported cases of malaria increased from 43, 533 in 2004 to about 62, 121 case in 2008. From the result also, malaria morbidity index revealed an increase of 0.005 annually between 2000 and 2008.

Yeshiwodim, et al (2009) carried out a research on spatial analysis of malaria incidence at the village level in areas with unstable transmission in Ethiopia from September, 2002 to August, 2006. Applying the method of poisson regressios analysis, the result showed the presence of significant spartio-temporal variation and also showed a decrease in the incidence of malaria with increasing age. The conclusion was that incidence of malaria varies according to gender and age, with males age 5 and above showing a statistically higher incidence.

Korenromp et al (2007) carried out a study titled "Forecasting Malaria Incidence based on monthly case reports and Environmental Factors in Karuzi Burudi, from 1997 to 2003". Using time series analysis, the result revealed that the exploration of the incidence of malaria, precipitation, temperature and vegetation for 1997 to 2003 showed no clear trend, and suggests a seasonal dependency in the series with a 6-month period for the incidence and a 12-month period for rainfall, temperature and vegetation.

Nwankwo and Okafor (2009) carried out a research on the effectiveness of Insecticide Treated bed Nets (ITN$_s$) in malaria prevention among children aged 6 months to 5 years in Umungwa Obowo L.G.A, Imo State of Nigeria

between June and September 2006. From the 100 children selected and randomly assigned either treated bed nets or traditional bed nets, and using a chi-square test of independence, the result revealed that there was a significant difference in the malaria morbidity situation among the two groups. That is to say, morbidity due to malaria was higher in children that used traditional bed nets than the other group.

Opara (2001) carried out a study titled "The effects of malaria during pregnancy on infant mortality in Abia State Nigeria between 1993 and 1999". Using chi-square test for independence, the result showed that malaria during pregnancy increased neonatal mortality by lowering birth weight.

Adebola and Okereke (2007) conducted a study titled "Increasing Burden of Childhood Severe Malaria in a Nigerian Tertiary Hospital: Implication for control, between January 2000 and December 2005". Using logistic Regression, the result showed that severe Malaria constituted an important cause of hospital admission among Nigerian children especially those aged below 5 years. The result also revealed that there was significant increase in the proportion of cases of severe malaria from 2000 to 2005.

Greenwood et al (2009) carried out a research on the evolution of malaria mortality and morbidity after the emergence of chloroquine resistance in rural area of the Gambia, West Africa between 1992 and 2004. Applying the method of univariate logistic regression and time series analysis, the result revealed that mortality attributable to malaria did not continue to increase dramatically, in spite of the growing resistance to chloroquine as first-line treatment, until 2003. The result also showed that malaria morbidity and mortality followed parallel trends and rather fluctuated accordingly to rainfall.

Baird, et al (2002) conducted a research on the seasonal malaria attack rates in infants and young children in northern Ghana from 1996 to 1997. Using fisher's exact test and chi-square test of independence, the result showed that the mean parasitemia count at the time of re-infection in the dry season roughly equalled that in the wet season.

DATA COLLECTION AND METHOD OF DATA ANALYSIS

DATA COLLECTION

The data collected for the purpose of this research work were purely secondary. The data were collected from, St. Joseph Hospital, Eziala Enyiogugu Aboh Mbaise Local Government Area of Imo State; and Hossana Hospital Logara, Ngor Okpala Local Government Area (L.G.A) of the same Imo State. Two hospitals were collected at random from the one hundred and seventy two private owned hospitals in Imo State, Nigeria. They comprise of the number of patients treated of Malaria and the number of patients that died from Malaria together with their gender, from the year 2000 to 2012. The data are as shown in Tables 2 and 3 (see Appendix IV).

PROBLEMS ENCOUNTERED

During data collection, a lot of problems were encountered, some of which include:

(i) **Unwillingness to release data:** Many of the hospitals visited for the purpose of data collection were unwilling to release the data as they said that the data were classified.

(ii) **Financial constraints:** A lot of money was spent on transportation as several visits were made before the data were eventually released.

(iii)   The data were not normally arranged and as a result of that, the researchers encountered problems of arranging them annually before collection.

(iv)   Finally, some of the records did not specify gender for patients, and as a result, the researchers used their initiatives to classify the patients through their names.

METHOD OF DATA ANALYSIS

The following statistical methods or techniques will be used for the data analysis in this study:-

(a)   Analysis of Variance (ANOVA)

(b)   Runs Test

(c)   Test for Equality of Population Proportions

(d)   Mortality Rate

ANALYSIS OF VARIANACE (ANOVA)

According to Inyama and Iheagwam (2006), analysis of variance is a term which describes a technique of dividing the total variation in an experimental procedure into meaningful components. The two major components usually distinguished are:

(a)   Variability between sample measuring systematic and random or chance variation.
(b)   Variability within samples measuring only random or chance variation.

Analysis of variance is used in testing for the difference of means of more than two populations using independent samples from normal population with common but unknown variance, where it is necessary to obtain a pooled estimate of the variance.

ASSUMPTIONS OF ANOVA

The basic assumptions of ANOVA include:

(a)   Each sample group is an independent random sample from a normal population
(b)   The sample groups come from population with equal variances.

ANOVA is Robust to the departures from normality although the data should be symmetric.

CLASSES OF ANOVA MODELS

There are three classes of ANOVA models, according to Sahai and Ageel (2000), they include:

(a) FIXED-EFFECTS MODELS (MODEL I)

This assumes that the data may differ only in their means.

(b) RANDOM – EFFECTS MODELS (MODEL 2)

This assumes that the data describe a Hierarchy of different populations whose differences are constrained by the hierarchy.

(c) MIXED-EFFECT MODELS (MODEL 3)

This describes the situations where both fixed and random effects are present.

TYPES OF ANALYSIS OF VARIANCE

Analysis of variance can be classified into:

(a)   Different forms of analysis (univariate ANOVA or multivariate ANOVA (MANOVA) according to the number of dependent variables.

(b)   Different types of Dimensions or ways (one-way, two-way, three-way) according to the number of independent variables.

For this research, the two-way analysis of variance will be used [The procedures for others are as outlined in Nwobi (2003 and 2006), Nwachukwu (2008), Inyama and Iheagwam (2006)].

TWO WAY ANALYSIS OF VARIANCE

According to Nwobi (2008), two-way analysis of variance is an extension of the one-way analysis of variance. The need for two-way analysis of variance arises as a result of two-factor experiments which do not readily lend themselves to one-way analysis of variance.

There are mainly two different ways of analyzing two-factor experiments. They depend on whether the variables are independent or whether they interact i.e., the case where the variables or treatments are not independent. To test for interaction of the treatments, more than one observation has to be included in each cell of two-way analysis data table (i.e. replication). If there are no interaction of the treatments, the two-way analysis of is called a randomized block design.

The two-way analysis of variance without interaction will be used in this study. [The procedure for two-way with interaction is as outlined in Inyama and Iheagwam (2006)].

TWO-WAY ANOVA WITHOUT INTERACTION

If y_{ij} for $i = 1, 2, \ldots, a$ and $j = 1, 2, \ldots, b$ are values of independent random variables having normal distributions with the respective means μ_{ij} and the common variance σ^2, the linear equation for the randomized block design is.

$$\mu_{ij} = \mu + \alpha_i + \beta_j + e_{ij} \qquad (1) \qquad i = 1, 2, \ldots, a; \ j = 1, 2, \ldots, b$$

Where

μ = the grand mean

α_i = the ith treatment effect

β_j = the jth block effect

$$\sum_{i=1}^{a} \alpha_i = 0 \qquad \dots (2)$$

$$\sum_{i=1}^{b} \beta_j = 0 \qquad \dots (3)$$

e_{ij} are the values of independent random variables having normal distribution with zero means and common variance σ^2.

ESTIMATION OF MODEL PARAMETERS

Regardless of whether the model is fixed or random, we estimate the parameters of the model by the method of least squares. The object here is to use the error term, i.e. to minimize the error term, so we minimize the error sum of squares.

From (1)

$e_{ij} = X_{ij} - \mu - \alpha_i - \beta_j$

$e_{ij}^2 = (X_{ij} - \mu - \alpha_i - \beta_j)^2$ Square both sides

$\sum_{i=1}^{a} \sum_{j=1}^{b} e_{ij}^2 = \sum_{i=1}^{a} \sum_{j=1}^{b} (X_{ij} - \mu - \alpha_i - \beta_j)^2$ Summing over i, j.

Let $Q = \Sigma\Sigma e_{ij}^2$ so that

$\dfrac{\partial Q}{\partial \mu} = -2\Sigma\Sigma (X_{ij} - \mu - \alpha_i - \beta_j)$ for minimization,

$\dfrac{\partial Q}{\partial \mu} = 0$ and so

$\Sigma\Sigma (X_{ij} - \hat{\mu} - \alpha_i - \beta_j) = 0$

$\Sigma\Sigma X_{ij} - \Sigma\Sigma \hat{\mu} - \Sigma\Sigma \alpha_i - \Sigma\Sigma \beta_j = 0$

$\Sigma\Sigma X_{ij} - ab\hat{\mu} - b\sum_{i=1}^{a} \alpha_i - a\sum_{j=}^{b} \beta_j = 0$ ..(4)

From the convention made in (2) and (3), equation (4) becomes

$$\Sigma\Sigma X_{ij} - ab\,\hat{\mu} = 0$$

$$\Sigma\Sigma X_{ij} = ab\,\hat{\mu}$$

$$\therefore \qquad \hat{\mu} = \frac{\Sigma\Sigma X_{ij}}{ab} = \frac{X_{..}}{ab} = \overline{X}_{..} \qquad \ldots \qquad (5)$$

This means that the estimate of μ is $\overline{X}_{..}$. To estimate α_i, we differentiate Q w.r.t. α_i. Here, we sum only over j since we are estimating the $\alpha_{i's}$ and for a minimum, we see $\dfrac{\partial Q}{\partial \alpha_i} = 0$

i.e. $\qquad \dfrac{\partial Q}{\partial \alpha_i} = -2\sum_{j=1}^{b}(X_{ij} - \mu - \alpha_i - \beta_j) = 0$

$$\Sigma X_{ij} - \sum_{j=1}^{b}\mu - \sum_{j=1}^{b}\alpha_i - \sum_{j=1}^{b}\beta_j = 0$$

$$\Rightarrow \qquad \sum_{j=1}^{b} X_{ij} - b\mu - b\mu$$

$$\therefore \qquad \hat{\alpha}_i = \frac{X_{i.}}{b} - \frac{b\mu}{b} = \overline{X}_{i.} - \mu$$

$$\therefore \qquad \hat{\alpha}_i = \overline{X}_{i.} - \overline{X}_{..} \qquad \ldots \qquad (6)$$

To estimate β_{ij}, we differentiate Q w.r.t. β_j. Here, we sum only over i since we are estimating the $\beta_{j's}$ and for a minimum, we see $\dfrac{\partial Q}{\partial \beta_j} = 0$

i.e. $\qquad \dfrac{\partial Q}{\partial \beta_j} = -2\sum_{i=1}^{a}(X_{ij} - \mu - \alpha_i - \beta_j) = 0$

$$\sum_{i=1}^{a}(X_{ij} - \mu - \alpha_i - \beta_j) = 0$$

$$\sum_{i=1}^{a} X_{ij} - a\mu - \sum_{i=1}^{a}\alpha_i - a\beta_j = 0$$

$$\sum_{i=1}^{a} X_{ij} - a\mu = a\beta_j$$

$$\therefore \qquad \hat{\beta}_j = \overline{X}_{.j} - \mu$$

$$\therefore \quad \hat{\beta}_j = \overline{X}._j - \overline{X}.. \quad \quad \dots \quad (7)$$

For the error term, recall

$$\hat{e}_{ij} = X_{ij} - \hat{\mu} - \hat{\alpha}_i - \hat{\beta}_j$$

$$= X_{ij} - \overline{X}.. - \overline{X}_i. + \overline{X}.. - \overline{X}._j + \overline{X}..$$

$$= X_{ij} - \overline{X}_i. - \overline{X}._j + \overline{X}.. \quad \dots \quad (8)$$

Notice that $\overline{X}..$ is the estimate of the general mean $\overline{X}_i.$ is the mean of the ith treatment and $\overline{X}._j$ is the mean of the jth treatment.

PARTITIONING THE SUM OF SQUARES

Since there is no interaction effect because of one observation (replication) per cell, we proceed as follows:

$$\hat{e}_{ij} = X_{ij} - \overline{X}_i. - \overline{X}._j + \overline{X}..$$

$$C = \frac{X..^2}{ab} = \frac{(\Sigma\Sigma X_{ij})^2}{ab} \text{ (Correction term)}$$

$$TSS = C_{ij} - C, \text{ where } C_{ij} = \Sigma\Sigma X_{ij}^2$$

$$SS_\alpha = C_i - C, \text{ where } C_i = \frac{1}{b}\sum_{i=1}^{a} X_i^2.$$

$$SS_\beta = C_j - C, \text{ where } C_j = C_i = \frac{1}{a}\sum_{j=1}^{b} X._j^2$$

$$SS_e = TSS - SS_\alpha - SS_\beta = C_{ij} - C_i + C$$

THE TEST HYPOTHESES

The two null and alternative hypotheses to be tested are that:

i. $H_0^1 : \alpha_i = 0 \,(\text{the treatments are equal to zero})$

       $H_1^1 : \alpha_i\text{'s} \neq 0 \,(\text{at least one of the } \alpha_i\text{'s is different})$

ii. $H_0^2 : \beta_j = 0 \,(\text{the block effects are all equal to zero})$

$$H_1^2 : \beta_j\text{'s} \neq 0 \left(\text{at least one of the } \beta_j\text{'s is different} \right)$$

THE TEST STATISTIC

The test statistic for a two – way analysis of variance without interaction is given by

$$F_{Trt} = \frac{MS_{Trt}}{MS_E} \qquad \ldots \qquad (9)$$

$$F_{Block} = \frac{MS_{Block}}{MS_E} \qquad \ldots \qquad (10)$$

They are as summarized in the ANOVA table on table 1.1.

ANOVA TABLE FOR A TWO-WAY ANALYSIS OF VARIANCE WITHOUT INTERACTION

TABLE 1.1: ANOVA Table (one observation per cell)

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F
Treatment	$a - 1$	SS_{Trt}	$SS_{Trt} / a - 1$	MS_{Trt} / MS_E
Block	$b - 1$	SS_B	$SS_B / b - 1$	MS_B / MS_E
Error	$(a-1)(b-1)$	SS_E	$SS_E / (a-1)(b-1)$	
Total	$ab - 1$	SS_T		

Where,
$$MS_{Trt} = \frac{SS_{Trt}}{k-1} \qquad \ldots \qquad (11)$$

$$MS_B = \frac{SS_B}{n - 1_0} \qquad \ldots \qquad (12)$$

$$MS_E = \frac{SS_E}{(a-1)(b-1)} \qquad \ldots \qquad (13)$$

SS_B could be obtained by the formula

$$SS_B = \frac{1}{a} \sum_{j=1}^{b} T_{.j}^2 - \frac{T^2}{ab} \quad \dots \quad (14)$$

Where

T_j is the total of all observation for the jth block

T is the grand total of all the observations and

$$SS_{Trt} = \sum_{i=1}^{a} \frac{T_{i.}^2}{b} - \frac{T..^2}{ab} \quad \dots \quad (15)$$

$$SS_T = \sum_{i=1}^{a} \sum_{j=1}^{b} X_{ij}^2 - \frac{T^2}{ab} \quad \dots \quad (16)$$

THE DECISION RULE

If $F_{Trt} \geq F_{\alpha;(a-1),(a-1)(b-1)}$, H_0 is to be rejected

Also

If $F_B \geq F_{\alpha;(b-1),(a-1)(b-1)}$, H_0 is to be rejected

RUNS TEST

There are many methods of testing for trend in time series, they include the sign test, runs test etc; but the runs test will be used in this study.

According to Nwobi and Nduka (2003), a run can be defined as a succession of identical symbol, which are followed and preceded by different symbols or by no symbols at all. The three types of runs include the positive, negative and zero runs.

THE TEST HYPOTHESES

The hypotheses to be tested are:

H_0: The sequence follows a random process (there is no trend)

H_1: The sequence does not follow a random process (there is the presence of trend)

THE TEST STATISTIC

The test statistic is given by

$$Z = \frac{R - \mu_r}{\delta_r} \qquad \dots \qquad (17)$$

Where μ_r = the mean of the runs given by the formula

$$\mu_r = 1 + \frac{2n_1 n_2}{n_1 + n_2} \qquad \dots \qquad (18)$$

And δ_r^2 = the variance of the runs given by the formula

$$\delta_r^2 = \frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)} \qquad \dots \qquad (19)$$

And

R = the total number of runs

n_1 and n_2 = the number of positive and negative runs respectively

THE DECISION RULE: H_0 is to be rejected if $\left| Z_{cal} \right| > Z_\alpha$

TEST FOR EQUALITY OF TWO POPULATION PROPORTIONS

According to Nwobi (2003), test for equality of two population proportions is a test used to find out whether two proportions from two populations are equal or one of the proportions is less or more than the other.

THE TEST HYPOTHESES

The null and the alternative hypotheses to be tested are:

$H_0 : P_1 = P_2 \ \text{or} \ P_1 \ P_2 = 0$ (the two population proportion s are equal)

$H_1^1 : P_1 \neq P_2 \ \text{or} \ P_1 - P_2 \neq 0$ (the two population proportion s are not equal)
   or

$H_1^2 : P_1 > P_2 \ \text{or} \ P_1 - P_2 > 0$ (The first proportion is greater th an the second)
   or

$H_1^3 : P_1 < P_2 \ \text{or} \ P_1 - P_2 < 0$ (The first proportion is less than the second)

THE TEST STATISTIC

The test statistic is the Z_{cal} which is given by:

$$Z_{cal} = \frac{P_1 - P_2}{\sqrt{\dfrac{P_1(1 - P_1)}{n_1} + \dfrac{P_2(1 - P_2)}{n_2}}} \qquad \ldots \qquad (20)$$

Where

P_1 and P_2 are the proportion of the first and second population, respectively; and

n_1 and n_2 are the number of observation in the first and second population, respectively.

THE DECISION RULE

H_0 is to be rejected if $\left| Z_{cal} \right| > Z_{tab}$, otherwise it is accepted.

Mortality Rate

According to Nwogu and Iwueze (2009), mortality rate is a measure of the number of deaths (in general, or due to a specific cause) in some population, scaled to the size of that population, per unit time. Mortality rate is typically expressed in units of deaths per 1000 individuals per year. Mortality rate is given by the formula

$$MR = \frac{\text{Number of Deaths of a specified year}}{\text{The number of people in the population}} \times 1000 \qquad \ldots \quad (21)$$

$$= \frac{\partial i}{Pi} \times 1000 \qquad \ldots \qquad (22)$$

Bartletts Test

The bartletts test is one of the methods of testing for equality of constant variance. The bartletts test statistic is given by

$$B = \frac{K}{1 + L} \qquad \ldots \quad (23)$$

where

$$Z_{cal} =$$

$$L = \frac{1}{3(a-1)} \left[\sum_{i=1}^{a} \frac{1}{n_i - 1} - \frac{1}{\sum_{i=1}^{a} (n_i - 1)} \right] \quad \dots \quad (24)$$

$$K = \sum_{i=1}^{a} (n_i - 1) \log_e [T_A] - \sum_{i=1}^{a} (n_i - 1) \log_e (S_i^2) \quad \dots \quad (25)$$

$$T_A = \frac{1}{\sum_{i=1}^{a} (n_i - 1)} \sum_{i=1}^{a} (n_i - 1) S_i^2 \quad \dots \quad (26)$$

Under the null hypothesis of constant variance the statistic in (23) follows chi-square distribution with $a - 1$ degrees of freedom. The null hypothesis of constant variance is rejected if the calculated value of B in (23) exceeds its chi-square tabulated of significance and $a - 1$ degrees of freedom.

DATA ANALYSIS

GRAPHICAL PRESENTATION OF DATA

The scatter plots of the original data were plotted for both the incidence of malaria and malaria mortality, respectively in Figures 1 and 2 (see Appendix II).

Also, the Normal probability plot, the residual against the fitted value were plotted for the incidence of malaria (see Fig. 1) and also for malaria mortality(see Fig. 2).

Table 1.2 Calculations for Shapiro Francia's Test

i	1	2	3	4	5	6	7	8	9	10	11	12	13
$y_{(i)}$	971	1064	1087	1105	1151	1170	1173	1195	1199	1213	1225	1239	1297
M_i	-2.2098	-1.1264	-0.8585	-0.6488	-0.1129	0.1084	0.1434	0.3997	0.4463	0.6094	0.7491	0.9122	1.5879

For $n = 13$, $k = 6$, the coefficients b_i, $i = 1, 2, \dots, 6$ are determined as

$$b_1 = \frac{0.3977}{\sqrt{12.00002}} = 0.11538 \; , b_2 = \frac{0.4463}{\sqrt{12.00002}} = 0.12884 \; , b_3 = \frac{0.6094}{\sqrt{12.00002}} = 0.17 \; ,$$

$$b_4 = \frac{0.7491}{\sqrt{12.00002}} = 0.21625 \; , b_5 = \frac{0.9122}{\sqrt{12.00002}} = 0.26333 \; , b_6 = \frac{1.5879}{\sqrt{12.00002}} = 0.45839$$

$$\sum_{i=1}^{k} b_{n-i+1} (y_{(n-i+1)-y(i)})$$

$$= 0.45839(1297 - 971) + 0.26333(1239 - 1064) + 0.21625(1225 - 1087) + 0.17592(1213 - 1105) +$$
$$0.12884(1199 - 1151) + 0.11538(1195 - 1170)$$

$$= 253.42857$$

and

$$\sum_{i=1}^{n} (y_i - \overline{y})^2 = 88,424.76923$$

Hence, the Shapiro – Francia Statistic W′ is given by

$$W' = \frac{(253.42857)^2}{88424.76923} = 0.7263$$

Since the critical values of the W′ statistic are not readily available, we employ a normal approximation. The statistic $\log_{10}(1 - W')$ is approximately normally distributed with mean $\hat{\mu} = -1.2725 + 1.052(v - u)$ and standard deviation $\hat{\sigma} = 1.0308 - 0.26758(v + \frac{2}{u})$ where $u = \log_e^{(n)}$ and $v = \log_e^{(u)}$. The values of the normal deviate $Z' = \{\log_e(1 - W') - \hat{\mu}\}/_{\hat{\sigma}}$ are referred to the upper-tail critical values of the standard normal distribution. Values of Z′ > 2.33 indicate departures from normality at the 1 percent significance level.

$$u = \log_e^{13} = 2.56495 \quad , \qquad v = \log_e^{2.56495} = 0.94194$$

$$\therefore \qquad \hat{\mu} = -1.2725 + 1.052(0.94194 - 2.56495) = -2.3799$$

$$\hat{\sigma} = 1.0308 - 0.26759\left(0.94194 + \frac{2}{2.56495}\right) = 0.5701$$

and

$$Z' = \{\log_e^{(1 - 0.7263)} - (-2.3799)\}/_{0.5701} = 1.90$$

Since Z′ < 2.33, the hypothesis of normality of treated cases of malaria patients is not rejected.

BARTLETTS TEST OF HOMOGENEITY OF VARIANCE

In testing for the assumption of constant variance used for this research work, it becomes necessary to employ the Bartlett's test.

Table 1.3: Computation of Bartletts Test

s/n	S_i^2	$\log_e s_i^2$	$(n-1)S_i^2$	$(n-1)\log_e s_i^2$
1	15150.5	9.6258	60602	38.5032
2	20463.8	9.9264	81855.2	39.7056
3	17529.2	9.7716	70116.8	39.0864
4	16960.8	9.7387	67843.2	38.9548
5	23200.5	10.0519	92802	40.2076
6	9022.7	9.1075	36090.8	36.4300
7	16317.5	9.7000	65270	38.8000
8	17783	9.7860	71132	39.1440
9	20182.7	9.9126	80730.8	39.6504
10	23644.8	10.0709	94579.2	40.2836
11	15030.8	9.6179	60123.2	38.4716
12	15942.2	9.6767	63768.8	38.7068
Total			910656.8	506.7728

Hypothesis Testing

$H_0 : \sigma_i^2 = 0 \quad \forall_i, i = 1, 2, 3, \ldots, 13$

$H_1 : \sigma_i^2 \neq 0 \quad \text{for at least one i}$

Using equation (26)

$$T_A = \frac{910656.8}{52} = 17512.63077$$

Using equation (25), we have

$$K = 52 \log_e^{17512.63077} - 506.7728 = 1.302438$$

Using equation (24)

$$L = \frac{1}{3(13-1)}\left[3.25 - \frac{1}{52}\right] = 0.08974$$

Using equation (23)

$$B = \frac{1.302438}{1 + 0.08974} = 1.1952$$

$$\chi^2_{12, 0.05} = 21.026$$

Since the calculated value does not exceed the chi-square tabulated at α = 0.05 level of significance, we accept the null hypothesis of constant variance, which agrees with one of the assumptions required. With this, it may not be necessary to transform of data. Thus, we proceed with the original data. Having satisfied the two assumptions, we can now proceed to the proper analysis.

TESTING FOR EQUALITY BETWEEN THE MEANS OF THE YEARS AND THE MEANS OF THE AGE GROUPS OF THE REPORTED CASES OF MALARIA IN IMO STATE

This test was done, using ANOVA from MINITAB Version 16.0 Software package, to determine whether there is a significant difference between the means of the years and the means of the age groups of the incidence of malaria and malaria mortality in Imo State (see Tables 2 and 3 in Appendix IV).

TESTING FOR EQUALITY BETWEEN THE MEANS OF THE YEARS AND THE MEANS OF THE AGE GROUPS OF INCIDENCE OF MALARIA IN IMO STATE

The null and the alternative hypotheses are of the form:

$$H_0^2 : \beta_{2000} = \beta_{2001} = \ldots = \beta_{2012} \ (\text{The incidence of malaria is equal across the years})$$
$$H_0^1 : \alpha_{(\leq 14)} = \alpha_{(15-35)} = \ldots = \alpha_{(78^+)} \ (\text{The incidence of malaria is equal for all age group})$$
$$H_1^2 : \beta_{2000} \neq \beta_{2001} \neq \ldots \neq \beta_{2012} \ (\text{At least one of the years is different})$$
$$H_1^1 : \alpha_{(\leq 14)} \neq \alpha_{(15-35)} \neq \ldots \neq \alpha_{(78^+)} (\text{At least one of the age group is different})$$

THE TEST STATISTIC (FOR THE YEARS)

From the Minitab output, the test statistic becomes, $F_{cal} = 1.85$ (see Appendix I).

CRITICAL VALUE

$$F_{tab} = F_{\alpha;(k-1),(a-1)(b-1)} = F_{0.05,12,48} \cong 1.97$$

DECISION

Since $F_{cal} (= 1.85) < F_{tab} (= 1.97)$, H_0 is therefore accepted.

CONCLUSION

The mean incidence of malaria does not differ significantly across the years. That is to say that the mean incidence of malaria is equal across the years under study.

THE TEST STATISTIC (FOR THE AGE GROUPS)

From the Minitab output, the test statistic becomes, $F_{cal} = 247.31$ (see Appendix I).

CRITICAL VALUE

$$F_{tab} = F_{\alpha;(k-1),(n-1)(k-1)} = F_{0.05,4,48} \cong 2.58$$

DECISION

Since $F_{cal} (= 247.31) > F_{tab} (= 2.58)$, H_0 is therefore rejected.

CONCLUSION

The mean incidence of malaria in Imo State differs significantly across the age groups. That is to say that the incidence of malaria is not equal across the age groups.

TESTING FOR EQUALITY BETWEEN THE MEANS OF THE YEARS AND THE MEANS OF THE AGE GROUPS OF MALARIA MORTALITY IN IMO STATE

The Test Hypotheses are:

$H_0^2 : \beta_{2000} = \beta_{2001} = \ldots = \beta_{2012}$ (Malaria mortality are equal across the years)

$H_0^1 : \alpha_{(\leq 14)} = \alpha_{(15-35)} = \ldots = \alpha_{(78^+)}$ (Malaria mortality are equal across age group)

$H_1^2 : \beta_{2000} \neq \beta_{2001} \neq \ldots \neq \beta_{2012}$ (At least one of the years is different)

$H_1^1 : \alpha_{(\leq 14)} \neq \alpha_{(15-35)} \neq \ldots \neq \alpha_{(78^+)}$ (At least one of the age group is different)

THE TEST STATISTIC (FOR THE YEARS)

From the Minitab output, the test statistic becomes $F_{cal} = 1.21$ (see Appendix II).

CRITICAL VALUE

$$F_{tab} = F_{\alpha;(a-1),(a-1)(b-1)} = F_{0.05,12,48} \cong 1.97$$

DECISION

Since $F_{cal} (= 1.21) < F_{tab} (= 1.97)$, H_0 is therefore accepted.

CONCLUSION

The mean malaria mortality, in Imo State, is equal across the years. That is to say, it does not differ significantly.

THE TEST STATISTICS (FOR THE AGE GROUPS)

From the Minitab output, the test statistic now becomes, $F_{cal} = 28.89$

CRITICAL VALUES

$$F_{tab} = F_{\alpha;(b-1),(a-1)(b-1)} = F_{0.05,4,48} \cong 2.58$$

DECISION

Since $F_{cal} (= 28.89) > F_{tab} = (2.58)$, H_0 is therefore rejected.

CONCLUSION

The mean of malaria mortality, in Imo State, differs significantly across the age groups. That is to say, malaria mortality is not equal across the age groups.

TESTING FOR THE PRESENCE OF TREND IN THE SERIES

This test was done to determine whether trend exist in the time series data collected. It was done for both the incidence of malaria and malaria mortality, respectively (see Table I in Appendix III).

TESTING FOR TREND IN THE INCIDENCE OF MALARIA IN IMO STATE

H_0:   The incidences of malaria in Imo State are randomly distributed (There is no trend)

H_1:   The incidences of malaria in Imo State are not randomly distributed (There is presence of trend)

THE TEST STATISTIC

Using the information on Table 1 of Appendix III, where

$$n_1 = 20, \quad n_2 = 45, \quad R = 8$$

The mean of the runs, μ_r is obtained using (18) as:

$$\mu_r = \frac{2(20)(45)}{20+45} + 1 = 28.69$$

The variance of the runs, δ_r^2, is also computed using (19) as;

$$\delta_r^2 = \frac{2(20)(45)[2(20)(45) - 20 - 45]}{(20 + 45)^2(20 + 45 - 1)} = 11.5496$$

Thus, the test statistic using (17) now becomes:

$$Z_{cal} = \frac{8 - 28.69}{3.3985} \cong -6.09$$

CRITICAL VALUE

$$Z_{tab} = Z_{\frac{\alpha}{2}} = Z_{\frac{0.05}{2}} = Z_{0.025} = -1.96$$

DECISION

Since $|Z_{cal}| = (6.09) > Z_{tab} = (1.96)$, H_0 is therefore rejected.

CONCLUSION

The incidence of malaria in Imo State also shows presence of trend, though the data were reported on time and could be said to be time dependent. That is to say, morbidity due to malaria can occur at any time of the year.

TESTING FOR TREND IN MALARIA MORTALITY IN IMO STATE

H_0: Malaria mortality are randomly distributed (there is no trend)

H_1: Malaria mortality are not randomly distributed (there is presence of trend)

THE TEST STATISTIC

Using the information on Table 1 of Appendix III,

where $n_1 = 39$, $n_2 = 26$, $R = 10$

The mean of the runs, μ_r, is obtained using (18) as:

$$\mu_r = \frac{2(39)(26)}{39 + 26} + 1 = 32.2$$

The variance of the runs, δ_r^2, is also obtained using (19) as,

$$\delta_r^2 = \frac{2(39)(26)[2(39)(26) - 39 - 26]}{(39 + 26)^2(39 + 26 - 1)} = 14.7225$$

Thus, the test statistic using (17) now becomes

$$Z_{cal} = \frac{10 - 32.2}{3.8370} \cong -5.79$$

CRITICAL VALUE

$$Z_{tab} = Z_{\frac{\alpha}{2}} = Z_{\frac{0.05}{2}} = Z_{0.025} = -1.96$$

DECISION

Since $\left| Z_{cal} \right| (= 5.79) > Z_{tab} (= 1.96)$, H_0 is therefore rejected.

CONCLUSION

The mortality cases of malaria shows presence of trend but it does not follow a clear pattern as the scatter plot showed a weak trend (see Figure 2(b) in Appendix II).

TESTS FOR EQUALITY OF TWO POPULATION PROPORTIONS

This test is used in this study to verify if the incidence of malaria as well as malaria mortality in Imo State is equal between males and females.

FOR THE INCIDENCE OF MALARIA IN IMO STATE

The test hypotheses are of the form;

$$H_0 : P_{males} = P_{females} \quad \left(\text{The incidence of malaria is equal for both sex} \right)$$

$$H_1 : P_{males} \neq P_{females} \quad \left(\text{The incidence of malaria is not equal for both sex} \right)$$

THE TEST STATISTIC

Using the information in Table 1.4 to obtain the sample proportions for the male and female populations, P_{males} and $P_{females}$ respectively as:

Table 1.4: Incidence of Malaria

GENDER	0-14	15-35	36-56	57-77	78^{+}	TOTAL
MALE	2652	1872	1092	1036	645	7297
FEMALE	2892	1934	1035	1220	711	7792
TOTAL	5544	3806	2127	2256	1356	15089

$$p_{males} = \frac{n_{males}}{N} = \frac{7297}{15089} = 0.484$$

$$p_{females} = \frac{n_{females}}{N} = \frac{7792}{15089} = 0.516$$

The test statistic, using Equation (20), now becomes

$$Z_{cal} = \frac{0.484 - 0.516}{\sqrt{\frac{0.484\,(1-0.484)}{7297} + \frac{0.516\,(1-0.516)}{7792}}} = -3.931$$

CRITICAL VALUE

$$Z_{tab} = Z_{\frac{\alpha}{2}} = Z_{\frac{0.05}{2}} = Z_{0.025} = -1.96$$

DECISION

Since $\left|Z_{cal}\right|\,(=3.931) > Z_{tab}\,(=1.96)$, H_0 is therefore rejected.

CONCLUSION

The incidence of malaria, in Imo State, is not equal between males and females.

FOR MALARIA MORTALITY IN IMO STATE

The test hypotheses are of the form:

$H_0 : P_{males} = P_{females}$ (Malaria mortality are equal for both sex)

$H_1 : P_{males} \neq P_{females}$ (*Malaria mortality are not equal for both sex*)

THE TEST STATISTIC

Using the information in Table 1.5 to obtain the sample proportions for the male and female populations, P_{males} and

$P_{females}$, respectively as:

Table 1.5: Malaria Mortality

GENDER	≤ 14	15-35	36-56	57-77	78+	TOTAL
MALE	134	86	85	62	39	406
FEMALE	112	77	69	52	38	348
TOTAL	246	163	154	114	77	754

$$p_{males} = \frac{n_{males}}{N} = \frac{406}{754} = 0.538$$

$$p_{females} = \frac{n_{fema\;;es}}{N} = \frac{348}{754} = 0.462$$

The test statistic, in equation, (20), now becomes

$$Z_{cal} = \frac{0.538 - 0.462}{\sqrt{\frac{0.538\,(1 - 0.538)}{406} + \frac{0.462\,(1 - 0.462)}{348}}} = 2.087$$

THE CRITICAL VALUE

$$Z_{tab} = Z_{\frac{\alpha}{2}} = Z_{\frac{0.05}{2}} = Z_{0.025} = -1.96$$

THE DECISION

Since $\left|Z_{cal}\right| (= 2.087) > Z_{tab} (= 1.96)$, H_0 is therefore rejected.

CONCLUSION

Malaria mortality is not equal between males and females in Imo State.

TEST FOR EQUALITY OF MORE THAN TWO POPULATION PROPORTIONS

This test is used in this study to verify if the proportions of the incidence of malaria and the proportions of malaria mortality, in Imo State, are equal across the age groups.

FOR THE INCIDENCE OF MALARIA IN IMO STATE

The test hypotheses are of the form:

$H_0 : P_{(\leq 14)} = P_{(15-35)} = ... = P_{(78+)}$ (The proportion s of the incidence of malaria are equal across the age groups)

$H_1 : P_{(\leq 14)} = P_{(15-35)} = ... = P_{(78+)}$ (The proportion s of the incidence of malaria are not equal across the age groups)

THE TEST STATISTIC

Using the information on Table 1.6 to obtain the sample proportions for the respective age groups and the χ^2_{cal} as:

Table 1.6: Incidence of Malaria

Age group	Observed (O_i)	Proportion $P_o = (\frac{O_i}{N})$	% Proportion	Expected (e_i)	P_e	% P_e	$(P_0 - P_e)^2 / P_e$
≤ 14	5544	0.3674	36.74	3017.8	0.2	20	14.0114
$15 - 35$	3806	0.2522	25.22	3017.8	0.2	20	1.3624
$36 - 56$	2127	0.1410	14.10	3017.8	0.2	20	1.7405
$57 - 77$	2256	0.1495	14.95	3017.8	0.2	20	1.2751
$78 +$	1356	0.0899	8.99	3017.8	0.2	20	6.0610
	15089			15089			24.4504

The test statistic, using Equation below, now becomes

$$\chi^2_{cal} = \sum_{i=1}^{n} (P_0 - P_e)^2 / P_e \cong 24.450$$

CRITICAL VALUE

$$\chi^2_{tab} = \chi^2_{\alpha, (n-1)} = \chi^2_{0.05, 4} = 9.448$$

DECISION

Since $\chi^2_{cal} (= 24.450) > \chi^2_{tab} (= 9.488)$; H_o is therefore rejected

CONCLUSION

The proportion of the incidence of malaria in, Imo State is not equal across age groups.

FOR MALARIA MORTALITY IN IMO STATE

The test hypotheses are of the form:

$H_O : P_{(\leq 14)} = P_{(15-35)} = ... = P_{(78+)}$ (The proportion s of malaria mortality is equal across the age groups)

$H_I : P_{(\leq 14)} \neq P_{(15-35)} \neq ... \neq P_{(78+)}$ (The proportion s of malaria mortality is not equal across age groups)

THE TEST STATISTIC

Using the information on Table 1.7 to obtain the sample proportions for the respective age groups and the   as:

Table 1.7: Malaria Mortality

Age Groups	Observed (o_i)	$P_o = (\frac{O_i}{N})$	% P_0	Expected (e_i)	P_e	% P_e	$(P_{0-}P_e)^2 / P_e$
≤ 14	246	0.3263	32.63	150.8	0.2	20.00	7.9758
15 – 35	163	0.2162	21.62	150.8	0.2	20.00	0.1312
36 – 56	154	0.2042	20.42	150.8	0.2	20.00	0.0088
57 – 77	114	0.1512	15.12	150.8	0.2	20.00	1.1907
78 +	77	0.1021	10.21	150.8	0.2	20.00	4.7922
Total	754			754			14.0987

The test statistic, using the Equation below, now becomes

$$\chi^2_{cal} = \sum_{i=1}^{n} (P_o - P_e)^2 \Big/ P_e \cong 14.099$$

CRITICAL VALUE

$$\chi^2_{tab} = \chi^2_{\alpha,(n-1)} = \chi^2_{0.05,4} = 9.488$$

DECISION

Since χ^2_{cal} $(= 14.099) > \chi^2_{tab}$ $(= 9.488)$, H$_0$ is therefore rejected.

CONCLUSION

The proportion of malaria mortality, in Imo State, is not equal across age groups.

12.8   MORTALITY RATE OF REPORTED CASES OF MALARIA IN IMO STATE

Using the test statistic as stated in equation (21), the mortality rates are calculated thus:

TABLE 1.8: The Mortality Rates of the Reported Cases of Malaria

Year	Reported Cases	Malaria Mortality	Mortality Rate
2000	1225	56	4.57%
2001	1297	69	5.32%
2002	1064	63	5.92%
2003	1173	76	6.47%
2004	1170	57	4.87%
2005	971	48	4.94%
2006	1105	61	5.52%
2007	1239	59	4. 76%
2008	1195	53	4.44%
2009	1151	51	4.43%
2010	1213	50	4.12%
2011	1087	51	4.69%
Total	1199	60	5.00%

The mortality rates of the reported cases of malaria in Imo State were presented in a bar chart in Figure 3.11 (see Appendix II)

OVERALL CONCLUSION

This study centred on the incidence and mortality rate of reported cases of Malaria in Imo State, Nigeria using private owned hospitals as a study case. Two hospitals were randomly selected out of the one hundred and seventy two (172) recognized hospitals in the state. The two hospitals selected randomly have really unveiled to us the real picture of the cases of mortality and treated cases of malaria in Imo State, Nigeria. Data were collected based on the treated and mortality cases of malaria patients, according to their ages and years of occurrence. The statistical techniques used in this study are valid, since it satisfied the assumptions behind them. Thus, findings from our analysis in this paper, revealed the following conclusions:

- The mean incidence of malaria does not differ significantly across the years. That is to say that the mean incidence of malaria is equal across the years under study.
- The mean incidence of malaria in Imo State differs significantly across the age groups. That is to say that the incidence of malaria is not equal across the age groups
- The mean malaria mortality, in Imo State Nigeria, is equal across the years. That is to say, it does not differ significantly.
- The mean of malaria mortality, in Imo State, differs significantly across the age groups. That is to say, malaria mortality is not equal across the age groups.
- The incidence of malaria, in Imo State Nigeria, is not equal between males and females.
- Malaria mortality is not equal between males and females in Imo State.

- The proportion of the incidence of malaria in, Imo State Nigeria is not equal across age groups.
- The proportion of malaria mortality, in Imo State, is not equal across age groups.

RECOMMENDATIONS

As a result of findings from the analysis in this paper and general knowledge, we make the following recommendations:

- Provision of mortuary services in the Private Hospitals in Imo State Nigeria will reduce the problem of carrying corpse to distance hospitals for preservation.
- Future researchers should employ some other sophisticated statistical software, like MATLAB, STATA latest version, MINITAB version 17.0, E-views and so on in their studies to reduce the stress in computations.
- Proper attention to the sick, especially to those requiring urgent attention instead of the bureaucratic procedures often adopted in the Private Hospitals Centers.
- There should be Proper attention to the sick, especially to those requiring urgent attention instead of the bureaucratic procedures often adopted in the Private Hospital centers.
- Future authors should try and conduct a research of this type using Government owned hospitals, and as well use many sample sizes.
- Drugs for treatment and prevention of malaria should be tested to ensure that they satisfy the roll-back malaria needs of the vast majority of the people at all levels of health drugs for which quality certification can be readily obtained from local institutions, from which the country of origin or through the auspices of the World Health Organization.
- Counterfeit drugs already in circulation should be mopped up.
- Having observed that the mortality rate of malaria for males is higher than that of their female counterpart in this study, the Government of Imo State, Nigeria; should look into the rational behind this ugly scenario and try to reduce it.

REFERENCES

Adebola P.A. and Okereke R.W. (2007). *Increasing Burden of childwood severe Malaria in a Nigeria Tertiary Hospital from 2000 to 2005.* An unpublished research work.

Ayeni, A. O., (2011). Malaria Morbidity in Akure, Southwest Nigeria: A Temporal Observation in a Climate Change Scenario. *Trends Applied Sci. Res., 6: 488-494*

Ayodele J.; Oluyemi S.; Amos P.; and Tuoyo O (2007). *Quantifying the Economic Burden of Malaria using the Willingness to Pay Approach.* An Article submitted to the Department of Economics, University of Illorin, Illorin, Nigeria

Baird, J.K.; Owusu Agyei S; Utz G.C.; Koram, K; Barcus M.J.; Jones, T.R.; Fryauff, D.F.; Binka, F.N.; Hoffman, S.L.; Nkruma, F.N. (2002). *Seasonal Malaria attack rates in infants and young children in Northern Ghana.* Naval Medical Research Center, Silver Spring, Maryland, USA.

Durueke A.P. (2005). *A Research on the incidence, management and bionomc of Malaria in children under 5 years of age in parts of Isiala Mbano L.G.A., Imo State, Nigeria.* Unpublished research work.

Ejezie, V., Reed, Z. & Smith, P. G. (1991). '*Measurement of malaria vaccine efficacy in phase iii trials: Report of a who consultation*', Vaccine 25 (28), 5115 { 5123}

Ezedinachi, E.N.N Alaribe, A.A.A., and Ejezie G.C. (1998). *The prevalence Salmonella antibody among malaria patients in Calabar. Journal of Medical Laboratory Science* **7**, 34-41.

Fleiss, J . L. (1973). *Statistical Methods for Rates and Proportions.* John Wiley and Sons, New York.

Gerristsen, A.; Kruger P; Van der Leo, M. and Grobusch, M. (2008). 'Malaria incidence in limpopo provincem, South Africa, 1998 – 2007', Malaria Journal 7(1). URL:http://www.malariajournal. com/content/7/1/162.

Greenwood, B.M.; Bradley, A.K.; Greenwood, A.M.; Byass, P.; Jammeh, K.; Marsh, K.; Tulloch, S.; Old eld, F.S. and Hayes, R. (2009). '*Mortality and morbidity from malaria among children in a rural area of the gambia, West Africa,'* American Journal of Tropical Medicine and Hygiene 81 (3), 478 – 486.

Guillet, A., Lubell, Y. & Hanson, K. (2001), `*Malaria eradication: the economic, financial and institutional challenge', Malaria Journal* 7 (Suppl 1), S11. URL: http://www.malariajournal.com/content/7/S1/S11

Hardeo, S. and Mohammed I.A. (2000). *The Analysis of Variance*. Sheridan Books, Inc; Birkhauser Boston.

Henderson D.A. (1999). *A successful eradication campaign: discussion. Reviews of infectious diseases*, 1982, 4: 923-924.

Inyama, S .C. and Iheagwam, V. A. (2006). *Statistics And Probability: A Focus on Hypotheses Testing* Perfect Strokes Global Ventures Owerri.

Koram, K.A. and Molyneux, M.E. (2007). *'When is "Malaria" Malaria? The Dierent Burdens of Malaria Infection, Malaria Disease, and Malaria-Like Illnesses'.* American Journal of Tropical Medicine and Hygiene 77 (6 Suppl).

Korenromp, E.; Kiniboro, B. and WHO (2007). *Forecasting Malaria incidence estimates at Burndi country level for the year 1997 to 2003 – draft report.* http://www.who.int/malaria/publications/atoz/incidence estimations2.pdf.

Mills, A.; Lubell, Y. and Hanson, K. (2008). "*Malaria eradication: the economic, financial and institutional challenge",* Malaria Journal 7 (Suppl 1), S11. URL:http://www.malariajournal.com/content /7/S1/S11

Nomeh F.O. (2008): *Statistical Analysis on malaria mortality in Enugu State Nigeria.* An unpublished B.Sc. Project submitted to the Department of Statistics, Nnamdi Azikiwe University, Awka, Anambra State.

Nwachukwu, V.O. (2008). *Principles of Statistical Inference.* Zelon Publishers, Port-Harcourt, Rivers State Nigeria.

Nwobi, F.N and Nduka, E.C. (2003). *Statistical Notes and Tables for Research.* Alphabet Nigerian Publishers.

Nwobi, F. N. (2008). *Statistics 2: Introductory Inference* Supreme Publishers, Owerri.

Nwobi F.N. (2008). *Statistical Methods.* Supreme Publishers, Owerri.

Nwogu, E.C. and Iwueze, I.S. (2009). *Introductory to Demography*. Supreme Publishers, Owerri.

Opara K.R. (2001). *Effect of Malaria during pregnancy on mortality in Abia State Nigeria between 1993 and 1999.* An unpublished B.Sc. Project submitted to the department of Statistics, Abia State University, Uturu, Abia State.

Ofovwe V.A. and Erejie R.T. (2001). *Bayesian analysis of two-component mixture distributions applied to estimating malaria attributable fractions', Journal of the Royal Statistical Society (Series C):* Applied Statistics 47 (4), 575{587}.

Onwujekwe A.S, Targett, G. & Greenwood, B. (2002), *Malaria vaccines and their potential role in the elimination of malaria',Malaria Journal 7* (Suppl 1), S10. URL: http://www.malariajournal.com/content/7/S1/S10

Sahal G.M. and Ageel P.H. (2001). *Malaria control in the twentieth century. American journal of tropical medicine and hygiene*, 1976, 25: 361-371.

Salako A.H. (2002). *Yekutiel P. Lessons from the big eradication campaigns. World health forum*, 1981, 2: 465-490.

Smith, T., Schellenberg, J. and Hayes, R. (2000), `*Attributable fraction estimates and case definitions for malaria in endemic areas', Statistics in Medicine* 13 , 2345{2358}.

Trevor, W. (2010). *Applied Business Statistics, Methods and Excel-Based Application.* EBLS/Clarendo Press Oxford London.

Yeshiwondim A.K; Gopal, S.; Hailemarian A.T.; Dengela, D.O.; Patel, H.P.: *Spatial analysis of Malaria incidence at the village level in areas with unstable transmission in Ethiopia. Int. J. Health Geogr 2009, 8:5. Pubmed Abstract.*

About the Authors:

Jude Opara

Jude Opara obtained his B.Sc. (Hons) and M.Sc. in Statistics from the Department of Statistics, Imo State University, Owerri, Nigeria. He also holds a Postgraduate Diploma certificate in Education from National Teachers' Institute in affiliation with the Usman Dan-fodio University, Kaduna, Nigeria. He has previously taught Business Mathematics and Statistics (Operations Research) at Allover Central Polytechnic, Obudu, Nigeria as a part time lecturer and currently teaches undergraduate students within the department of statistics at the Imo State University, Owerri Nigeria.

Anderson Chukwukailo Nwobi

Anderson Nwobi holds a B.Sc. (Hons) in Statistics from the Department of Statistics, University of Ilorin Nigeria and an M.Sc. in Statistics from the Department of Statistics, Imo State University, Owerri, Nigeria. His lecturing experiences have included time at both the Sokoto Polytechnic and also the Kaduna Polytechnic both in Nigeria where he taught among others, Design and Analysis of Experiments. Anderson Nwobi also holds a Postgraduate Diploma certificate in Education from the National Teachers' Institute, in affiliation with the Usman Dan-fodio University, Kaduna, Nigeria. He is currently a Senior Lecturer in the Department of Statistics, Abia State Polytechnic, Aba, Nigeria.

Andrew Iheagwara

Andrew Iheagwara obtained his Ordinary National Diploma (OND) in Statistics and Mathematics from the Yaba College of Technology, Lagos, Nigeria and thereafter, his Higher National Diploma (HND) from the Department of Statistics at the Institute of Management and Technology (IMT), Enugu State, Nigeria. Andrew Iheagwara further obtained a Postgraduate Diploma (PGD) in Statistics and a Masters Degree from the Imo State University, Owerri, Nigeria. He also holds a Postgraduate Diploma certificate in Education from the National Teachers' Institute, in affiliation with the Usman Dan-fodio University, Kaduna, Nigeria. He is currently the director of Planning, Research and Statistics at the Imo State Ministry of Petroleum and Environment, Nigeria.

(MINITAB Output for Treated Cases of Malaria Patients)

Two-way ANOVA: Response versus Fac 1, Fac 2

Source DF   SS   MS   F   P

Fac 1 12 19487   1624   1.85 0.066

Fac 2   4 868514 217128 247.31 0.000

Error 48 42143   878

Total 64 930144

S = 29.63   R-Sq = 95.47%   R-Sq(adj) = 93.96%

Individual 95% CIs For Mean Based on

Pooled StDev

Fac 1   Mean --+---------+---------+---------+-------

 1   245.0   (-------*------)

 2   265.4   (-------*------)

 3   212.8   (-------*------)

 4   234.6   (-------*-------)

 5   234.0   (-------*------)

 6   194.2 (------*-------)

 7   221.0   (------*-------)

 8   247.8   (-------*------)

 9   239.0   (------*-------)

10   230.2   (-------*------)

11   242.6   (------*-------)

```
12   217.4        (------*------)

13   239.8           (-------*-----)

       --+---------+---------+---------+-------

         175     210     245     280
```

Individual 95% CIs For Mean Based on

Pooled StDev

```
Fac 2   Mean  -+---------+---------+---------+--------

1    428.769                      (-*-)

2    292.769             (*-)

3    163.615    (*-)

4    173.538    (*-)

5    104.308  (*-)

         -+---------+---------+---------+--------

          100     200     300     400
```


Fig. 1: Graphs of versus order (a), Normal Probability (b) and Versus Fits(c) for Number of Patients Treated of Malaria

Note: (a) means graph of residual against Observation order

(b) means graph of percent against Residual and (c) means graph of residual agaist fitted value, all for number of patients treated of malaria.

(MINITAB Output for Mortality Cases of Malaria Patients)

Two-way ANOVA: Response versus Fac 1, Fac 2

Source DF   SS   MS   F   P

Fac 1 12 155.20 12.933 1.21 0.302

Fac 2   4 1232.52 308.131 28.89 0.000

Error 48 511.88 10.664

Total 64 1899.60

S = 3.266   R-Sq = 73.05%   R-Sq(adj) = 64.07%

```
          Individual 95% CIs For Mean Based on

          Pooled StDev

Fac 1  Mean  --------+---------+---------+---------+-

 1    11.2       (--------*---------)

 2    13.8           (---------*---------)

 3    12.6        (---------*---------)

 4    15.2             (---------*-------)

 5    11.4        (---------*---------)

 6     9.6 (---------*---------)

 7    12.2        (---------*-------)

 8    11.8        (--------*---------)

 9    10.6     (--------*---------)

10    10.2     (---------*---------)

11    10.0     (--------*---------)

12    10.2     (---------*---------)

13    12.0        (---------*---------)

          --------+---------+---------+---------+-

            9.0    12.0    15.0    18.0
```

Individual 95% Cis For Mean Based on

Pooled StDev

```
Fac 2    Mean  --+---------+--------+---------+------
1    18.9231                    (---*--)
2    12.5385           (---*---)
3    11.8462        (---*--)
4     8.7692    (---*--)
5     5.9231  (---*--)

             --+---------+--------+---------+------
            5.0    10.0    15.0    20.0
```

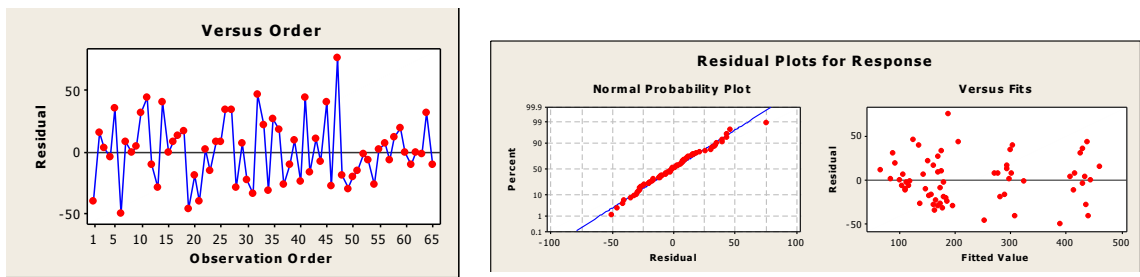### Fig. 3: SIMPLE BAR CHART FOR MORTALITY RATE
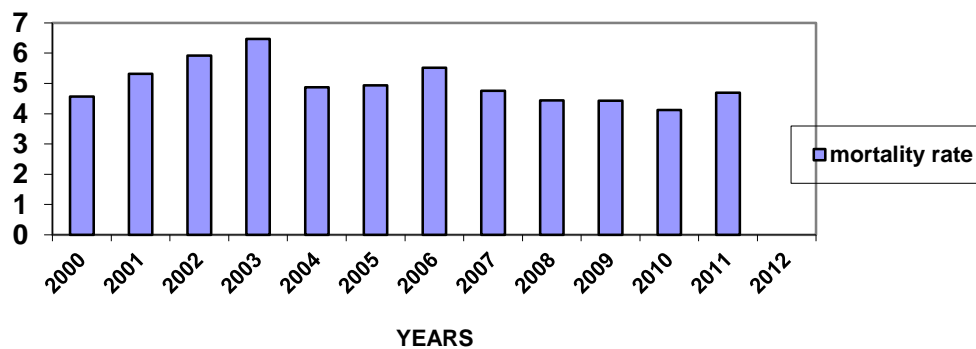
Fig. 2: Graphs of versus order (a), Normal Probability (b) and Versus Fits (c) for Number of Patients that died of Malaria.

Note: (a) means graph of residual against Observation order

(b) means graph of percent against Residual and (c) means graph of residual agaist fitted value, all for number of patients that died of malaria.
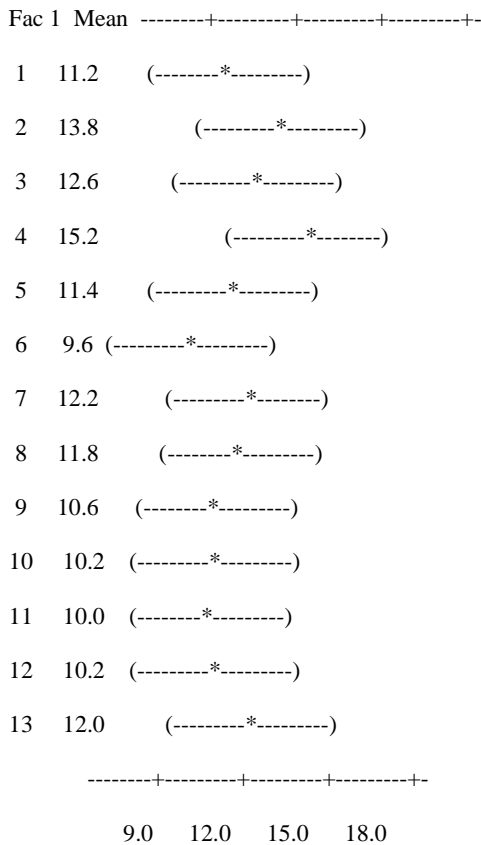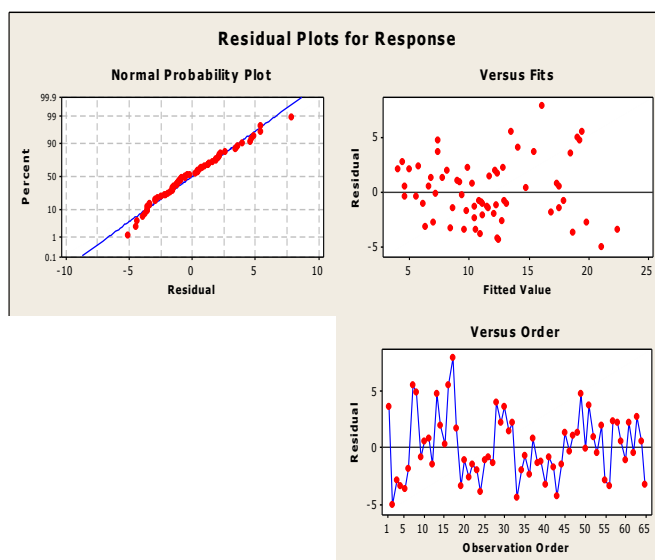
Table 1: Signs for computation of the Runs test for both Malaria Mortality and Incidence of Malaria.

S/N	MALARIA MORTALITY	SIGN	INCIDENCE OF MALARIA	SIGN
1	22	+	400	+
2	16	+	476	+
3	17	+	412	+
4	19	+	426	+
5	15	+	465	+
6	15	+	340	+
7	25	+	425	+
8	24	+	443	+
9	17	+	439	+
10	18	+	457	+
11	18	+	482	+
12	16	+	402	+
13	24	+	407	+
14	14	+	345	+
15	15	+	324	+
16	19	+	280	+
17	24	+	307	+
18	14	+	310	+
19	7	-	208	-
20	12	+	262	+
21	10	-	267	+
22	10	-	300	+
23	9	-	274	+
24	7	-	310	+
25	10	-	285	+
26	12	+	334	+
27	10	-	209	-
28	18	+	167	-
29	15	+	150	-
30	19	+	142	-
31	13	+	130	-
32	12	+	171	-
33	8	-	173	-
34	10	-	147	-
35	10	-	196	-
36	8	-	178	-

37	11	-	146	-
38	9	-	138	-
39	11	-	180	-
40	5	-	161	-
41	10	-	250	+
42	8	-	136	-
43	8	-	186	-
44	7	-	166	-
45	8	-	175	-
46	9	-	134	-
47	10	-	264	+
48	9	-	160	-
49	12	+	141	-
50	7	-	163	-
51	11	-	142	-
52	10	-	178	-
53	5	-	110	-
54	10	-	110	-
55	4	-	86	-
56	6	-	112	-
57	8	-	99	-
58	6	-	77	-
59	7	-	111	-
60	5	-	118	-
61	7	-	100	-
62	4	-	101	-
63	7	-	112	-
64	5	-	120	-
65	3	-	100	-
TOTAL	754		15119	

Note: the table above was computed using tables 2 and 3 (see Appendix IV)

Mean $= \dfrac{754}{65} = 11.6$ (For malaria mortality), $n_- = 39$, $n_+ = 26$, $R = 10$

Mean $= \dfrac{15119}{65} = 232.6$ (For incidence of malaria), $n_- = 20$, $n_+ = 45$, $R = 8$

Table 2: RECORDS OF THE NUMBER OF PATIENTS TREATED OF MALARIA FROM THE TWO

HOSPITALS

Year	0 – 14		15 – 34		35 – 54		55 – 74		75 +		Total		Grand
	M	F	M	F	M	F	M	F	M	F	M	F	Total
2000	202	198	182	163	108	101	89	72	60	50	641	584	1225
2001	196	280	142	182	78	89	92	158	42	68	550	747	1297
2002	198	214	132	148	92	58	64	72	52	34	538	526	1064
2003	218	208	169	138	73	69	99	87	63	49	622	551	1173
2004	198	267	141	169	52	78	64	102	41	58	496	674	1170
2005	172	168	87	121	92	79	96	79	28	49	475	496	971
2006	153	272	141	121	82	91	48	86	58	59	476	629	1105
2007	211	232	153	114	79	68	92	172	46	72	581	658	1239
2008	231	208	132	168	102	94	68	92	32	68	565	630	1195
2009	215	242	146	128	86	92	73	68	49	52	569	582	1151
2010	248	234	148	162	68	78	91	72	63	49	618	595	1213
2011	216	186	137	148	92	46	68	74	68	52	581	506	1087
2012	194	213	162	172	88	92	92	86	49	51	585	614	1199
Grand Total	2652	2892	1872	1934	1092	1035	1036	1220	645	711	7297	7792	15089

Source: Records and statistics department of the two hospitals.

Table 3: RECORDS OF THE NUMBER OF PATIENTS THAT DIED OF MALARIA IN THE TWO

HOSPITALS

Year	0 – 14		15 – 34		35 – 54		55 – 74		75 +		Total		Grand
	M	F	M	F	M	F	M	F	M	F	M	F	Total
2000	15	7	6	8	4	6	3	2	3	2	31	25	56
2001	8	8	10	5	11	7	4	6	6	4	39	30	69
2002	8	9	11	8	9	6	5	3	1	3	34	29	63
2003	11	8	13	11	10	9	2	6	4	2	40	36	76
2004	8	7	8	6	7	6	3	4	5	3	31	26	57
2005	9	6	4	3	8	4	5	3	2	4	28	20	48
2006	16	9	5	7	6	2	7	2	5	2	39	22	61
2007	14	10	4	6	5	5	5	5	1	4	29	30	59
2008	9	8	5	5	4	6	6	3	3	4	27	26	53
2009	8	10	6	3	3	5	7	5	2	2	26	25	51
2010	11	7	5	2	7	4	3	4	3	4	29	21	50
2011	6	10	4	6	5	4	6	5	2	3	23	28	51
2012	11	13	5	7	6	5	6	4	2	1	30	30	60
Grand Total	134	112	86	77	85	69	62	52	39	38	406	348	754

Source: Records and statistics department of the two hospitals.