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**Evaluation of Infant Mortality Rate Using Binary Logistic Regression “A Case study of Specialist Hospital Gombe”**

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**ABSTRACT**

*This research evaluates the significant causes of infant mortality rate which has become the main factor for the death of children below one year in our society today. Therefore it is very important to make a research in order to provide a source of information to the government, with the objective of finding lasting solutions to the problem and if possible, to eradicate it completely. The method used for this research is binary logistic regression; also we used accuracy, sensitivity and specificity to evaluate the model where binary response variable is related to a set of explanatory variables. The result shows that, there is significance difference in infant mortality rate from 2006 to 2015. Based on the outcome we conclude that infant mortality is still high in Gombe and need the government, non-governmental and societal attention.*

**Keywords:** Infant, Mortality, Binary, Logistic and Specificity.

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**1. INTRODUCTION**

Infant mortality is defined as the death of a child before his or her first birth day or the death of a child before the age of one year (Campbell & Graham, 2006). It is a useful indicator on the nation's health because it is often associated with other health factors such as maternal health, quality and accessibility of medical care and socio economic condition.

According to the maternal and child health survey by the UNICEF in 2013, Nigeria loses about 2,300 under five years old and 145 women of child bearing age in every a day, making it the second largest contributor to under five maternal mortality rate in the world. NDHS, (2003) At least, 6.3million

children under the age of five die across the world in 2013, nearly 17,000 a day. The death of newborn babies (infant) in Nigeria is about a quarter of the total number of deaths of children under five, about 9 out of 10 newborn death is curable, most of the deaths occur during pregnancy delivery reflecting the intimate link newborn survival and the quality of maternal care. Also 70 percent of the estimated one million under five years death is caused by preventable curable diseases such as typhoid, malaria, pneumonia, diarrhea, measles and H.I.V/AIDS. Malnutrition is another cause of morbidity and mortality in Nigeria, it account for at least 50 percent of children deaths. Poor environmental hygiene, access and utilization of quality health care services

by women and children are additional factors.

To many, it is just statistics, but to thousands of families who lost their children, mothers, wives and sisters, it goes beyond that. One would never understand the grieve and misery of losing a loved one to avoidable death. The government is making progress in cutting down infant mortality rates, but there is still a lot to be done to attain the millennium development goals of reducing child mortality by 30 percent at the end of 2015, with a 13 percent immunization rate for children between 12 to 23 months, Nigeria has the lowest vaccination rate in Africa. The recurring issue needs to be urgently addressed; the wellbeing of children and women in our respective states should be our prime focus now. Nigeria needs to integrate maternal, newborn and child health interventions into our health care services. Government should support data generation to ensure evidence based policies and interventions and make sure they are spread nationwide. It is important to note that wide regional disparities exist in child health indicators with the north east and north west geopolitical zones of the country having the worst child survival rate of 1,549/100,000 live births, compared to 165/100,000 in the south west zone almost 10 times difference (Hill, Thomas, & Abourzahr, 2007).

For any state or country who wants to achieve the objective of the world health organization (WHO), that is reduction on the risk associated with infant mortality rate, such a state or country must equip all the health care services in it state or her country. This work or research will focus on the factors responsible for high infant mortality rate in Gombe metropolis using specialist hospital as a case study. Despite the fact that maternities and health centers had been established in almost every ward in the state

for safe delivery of children in the health sector, infant mortality is still very high. Therefore, it is very important to make research that will serve as a source of information to Gombe state government and the entire people of the state on the ways to minimize and prevent the causes of children mortality and if possible to find a lasting solution to the problem.

Studies have been carried out in many countries on infant mortality, such studies either reveal the causes, risk factors or effect on infant and mortality. In some other studies the rates of mortality in different countries were revealed. "The Nigerian multiple indicator cluster survey 2007, (MIC,NBS,UNICEF) report that some progress have been made despite the economic and political climate. For example the infant mortality rate was 86 while the under-five mortality rate was 138 compared with 191 in 2006. The Nigeria male child has greater probability of dying as an infant or as under-five than his female counterpart, 92 versus 79 per 1000 at infant and 44 versus 131 per 1000 live births at under five respectively". Infant mortality increases from rural to urban sector of the population (94 to 62 percent per 1000) from the non-educated to secondary school or higher educated mother 94 to 63 from the richest to the poorest households (101 to 54 per 100).

The magnitude of infant mortality rate is perhaps the greater social injustice of our time. Children and mothers are dying because those who have the power to provide necessary help choose not to act. Our inability to act positively is a larger social injustice of discrimination against child and denial of women's human rights. This indifference by politician, policymakers, researchers and civil society is a betrayal of our collective hope for a stronger and more just society, one that

value every life no matter how young or hidden from public view that life might be.

No woman should die in the process of giving us life. We have voice, platform and instrument for radical change. Infant mortality rate are indicators for measuring development of any country, hence, Infant health is a national priority in combating extreme poverty and hunger (MDGs).

## 2. MATERIALS AND METHOD

The data used for this study were drawn from the record department of the specialist hospital Gombe. The data includes years, months, sex, and causes of deaths in infants ranging from 2006 to 2015 on monthly basis. Binary logistic regression is special type of regression where binary response variable is related to asset of explanatory variables which can be discrete or continuous. The important point here to note is that in linear regression, the expected values of the response variable are modeled based on combination of values taken by the predictors. In logistic regression, probability or odds of the response taken in a particular value is modeled based on combination of values taken by predictors. We make an explicit distinction between a response variable and one or more predictor (explanatory) variables. We begin with a two way tables then to three way tables, where all explanatory variables are categorical. Then we introduce binary logistic regression with continuous predictors as well.

Binary logistic regression requires the dependent variable to be binary. Since logistic regression assumes that  $P(y=1)$  is

the probability of an event occurring, It is necessary that the dependent variable is coded accordingly. That is, for binary regression, the factor level one of the dependent variable should represent the desired outcome.

## 3. BINARY LOGISTIC REGRESSION MODEL

$$\pi_i = p_r \left( Y_i = \frac{1}{x_i} \right) = \frac{\exp(\beta_0 + \beta_{1x})}{1 + \exp(\beta_0 + \beta_{1x})} \quad (1)$$

Or,

$$\log(\pi_i) = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = \beta_0 + \beta_i x_i \quad (2)$$

Where;

$Y_i$  is the response variable,

$X_i$  is the explanatory variable for observation? It can be discrete or continuous.

### 3.1. Summary of Assumptions.

1. The data  $Y_1, Y_2, Y_i$  are independently distributed.
2. Distribution of  $Y_i$  is Bin ( $n_i, \pi_i$ )
3.  $\pi_i = \Pr(Y_i = 1/x_i)$  =probability that the characteristic is present in observation  $i$ , given the value of the explanatory variable  $X_i$ .

### 3.2. Parameter Estimation.

The maximum likelihood estimation (MLE) for  $(\beta_0, \beta_1)$  obtained by finding  $(\beta_0, \beta_1)$  that maximizes

$$L(\beta_0, \beta_1, \beta_2, \beta_3) = \prod_{i=1}^N \pi_i^{n_i - y_i} (1 - \pi_i)^{y_i} = \prod_{i=1}^N \frac{\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3)}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3)} \quad (3)$$

In general, there are no close form solutions ,so the ML estimates are obtained by using iterative logarithms such as Newton Rapson (NR),Iteratively reweighted least squares (IRWLS),etc.

**3.3. Comparing Different Logistic Regression Models Via Likelihood Ratio Test.**

First, we review the general set-up, where

*Ho:* the probability of the characteristics depends on the j<sup>th</sup> variable.

*Ha:* the probability of the characteristics does not depend on the j<sup>th</sup> variable.

This achieved by comparing two models.

**3.4. Reduced Model**

$$\log \frac{\pi_i}{1-\pi_i} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \dots + \beta_{j-1} x_{j-1i} \tag{4}$$

Which contain all variables except the variable of interest j.

**3.5. Full Model**

$$\log \frac{\pi_i}{1-\pi_i} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \dots + \beta_{j-1} x_{j-1i} + \beta_j x_{ji} \tag{5}$$

Which contain all variable of interest j. The fit of each model to the data is assessed by the likelihood or equivalently, the log likelihood. The larger the likelihood, the better the model fit the data.

**3.6. Omnibus Chi- Square Test.**

The omnibus chi square test is a log – likelihood ratio test for investigating the model coefficients in logistic regression .The test procedures are as follows;

*Ho:* the model coefficients are not statistically significant.

*Ha:* the model coefficients are statistically significant.

Test statistic;

$$\chi^2 = 2 \left[ \sum_{i=1}^r \sum_{j=1}^c O_{ij} \ln \left( \frac{O_{ij}}{C_{ij}} \right) \right] \tag{6}$$

$$\chi^2 = 2 \left[ \sum_{i=1}^r \sum_{j=1}^c O_{ij} \ln O_{ij} - \sum_{i=1}^r R_i \ln R_i - \sum_{j=1}^c C_{ij} \ln C_{ij} n \ln n \right] \tag{7}$$

Decision rule

Reject Ho if P<0.05, otherwise accept Ho at 5% level of significance.

**3.7. Wald Test.**

The Wald test is used to test the statistical significance of each coefficient (β) in the logistic model. A Wald test calculates a Z statistic which is;

$$W = \frac{\hat{\beta}}{SE(\hat{\beta})} \tag{8}$$

This value is squared which yields a chi – square distribution and is used as a Wald test statistic.

Decision rule; Reject Ho (the null hypothesis that the coefficient is equal to zero) when the p-value of that coefficient is less than α is less level of significance.

**3.8. Evaluation of the Model**

Binary logistic regression built in this study or research evaluates in terms of their classification accuracy, sensitivity, and specificity. The classification accuracy measures the potion of cases correctly specified, sensitivity measures fraction of

positive cases that are classified as positive cases and specificity measures the fraction of negative cases that is classified as negative. This study used Forgaty and Bamber (2005), the formula to evaluate the models is;

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \quad (9)$$

$$\text{Sensitivity} = \frac{TP}{TP + FN} \quad (10)$$

$$\text{Specificity} = \frac{TN}{FP + TN} \quad (11)$$

$$\text{Positive predicted value} = \frac{TP}{TP + FP} \quad (12)$$

$$\text{Negative predicted value} = \frac{TN}{TN + FN} \quad (13)$$

Where TP, TN, FP and FN denotes true positive, true negative, false positive, and false negative respectively

### 3.9. Receiver Operating Characteristics Curve.

After evaluation of the model, receiver operating characteristic curve (ROC) is used to determine the overall accuracy of the model. This is done by plotting the true positive rate (sensitivity) against the false positive rate (1 – specificity) at different cut-off point. Each point on the ROC plots represents a sensitivity / specificity pair corresponding to the particular decision threshold. The model have perfect discrimination when the ROC plot passes through the upper left corner (100% sensitivity , 100% specificity) the closer the ROC plot is to the upper left corner, the higher the overall accuracy of the model (Zweig and Campbell 1993).Area 0.90 to 1.00 indicate excellent model ,0.80 to 0.89

indicates a very good model.0.70 to 0.79 indicates a good model.0.60 to 0.69 a fair model and area less than or equal to 0.59 indicates a poor model which fail to discriminate between disease and non-disease patient. This classification was given by traditional academic point system and in this study to evaluate or determine the overall accuracy of the model

### 4. Presentation and Discussion of Results

**Table 4.1:Dependent Variable Encoding**

Original Value	Internal Value
DEATH ABSENT	0
DEATH PRESENT	1

In table 4.1, indicates that the value code (0) represent a case that there is no death and the value code (1) represent a case that there is death.

**Table 4.2: Omnibus Chi-Square Tests for infant mortality**

	Chi-square	d.f	Sig.
Step 1 Step	73.339	3	.000
Block	73.339	3	.000
Model	73.339	3	.000

Table 4.2, shows the model analysis of chi square with 3 df, a value of 73.339 and p<0.05. Thus, we reject the null hypothesis and accept alternative hypothesis that there is significant difference between age and gender.

**Table 4.3: Classification Table for Infant Mortality Rate**

Observed			Predicted		
			INFANT_MORTALITY		Percentage Correct
			DEATH ABSENT	DEATH PRESENT	
Step 1	Infant_Mortality	Death absent	16	6	72.7
		Death present	4	94	95.9
		Overall Percentage			91.7

a. The cut value is .500

Table 4.3, documents the validity of predicted probabilities. The first two rows in the table represent two possible outcomes and the column under the heading ‘predicted’ is for high and low probabilities based on the cutoff points. The cutoff point may be specified by the researchers or set at 0.5 by S.P.S.S. According to the above table, with the cutoff point at 0.5, the prediction for infant who were present is 95.9% and for those who were absent is 72.7% for mortality in the hospital was have more than 50% validity. This observation was also supported by the magnitude of sensitivity (95.9%) compared to that specificity (72.7%). Sensitivity measures the proportion of correctly classified events (i.e.

death present for mortality case in the hospital for the period of ten years), whereas, specificity measures the proportion of correctly classified no death occurs (i.e. death absent or non-occurrence of mortality in the hospital). False positive rate is 20% and false negative rate is 6% which shows that the percentage is very low. The false positive rate measures the proportion observations misclassified as death occur over all of those classified as events. The false negative therefore measures the proportion observations misclassified as no death occur over all of those classified as no death occur. (Correction prediction was 91.7%, an improvement over the chance level).

**Table 4.4: Variables in the Equation for infant mortality**

	B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 <sup>a</sup>						
MALE	1.116	.298	14.070	1	.000	3.053
FEMALE	1.186	.344	11.869	1	.001	3.273
AGE_BY_MONT HS	.294	.178	2.720	1	.099	1.342
Constant	-3.968	1.175	11.397	1	.001	.019

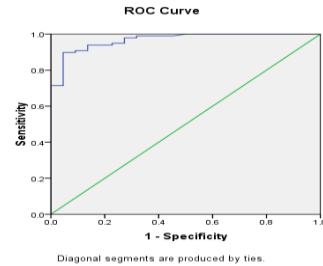
a. Variable(s) entered on step 1: MALE, FEMALE, and AGE BY MONTHS.

$$\log(\pi_i) = \frac{e^{-3.968+1.116(male)+1.186(female)+0.294(age)}}{1 + e^{-3.968+1.116(male)+1.186(female)+0.294(age)}} \quad 4.1$$

Table 4.4, shows the independent variables with the probabilities of Wald statistics less

than or equal to the level of significance of 0.05 hold significant relationship with the dependent variable. The insignificant variable have probabilities of Wald statistics greater than level of significance of 0.05 and

is the age by month in this analysis, if a coefficient is negative, the model is less likely to occur male or female and age have a positive effect on a variable. The positive effect will increase the logit of variables by 1.116, 1.186 and 0.294.



**Figure 4.1: receiver operative curve for Infant mortality**

**Table 4.5: Test Result Variable(s) for infant mortality**

Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.968	.016	.000	.936	.999

In Table 4.5, the Binary Linear Regression model has area under curve 0.968 which indicate excellent discriminating ability. This shows that the model performed excellently significant.

**5.0. INTERPRETATION OF RESULT**

In general, omnibus chi-square shows that there is significant differences between the variables, also the coefficients are significant except age by months which has significant value >0.05 and ROC curve has an area of 0.968 signifying an excellent discriminatory ability. Hence the infant mortality rate in Gombe state is highly significant which need the attention of government to provide the way out so that the high rate will reduce. In addition infant mortality is cause by many factors such as poverty, negligence of the parents, illiterate, lack of awareness and sensitivity by the appropriate body, attitude of some workers towards there patient or client and non-respond of the professional toward the emergency cases. Such factors and others contribute to high mortality rate in Gombe state and the country in large.

**6.0. CONCLUSION**

Infant survival should be a major policy among the goals of the Gombe state government, Nigeria and the world at large, because of the multiple short-term and long term effects on human and economic development for the progress of the society. A global initiative is imperative in the wider context of the required progress towards relevant millennium Development Goal (MDGS).

It is of interest to note that in the 21<sup>st</sup> century, we are able to transport to the moon, we are able to do stem research for diseases E.T.C, yet we seem incapable of counting evaluating infant mortality rate in developing countries like Nigeria and our state Gombe state. The health status in our state will never be understood until the void in vital statistics is addressed. I suggest that better counting and evaluation of infant mortality rates can be improved and are given prioritized policy action by the government, MDGS and individuals. Binary

logistic regression is among the best method for evaluating present or absent of a variables, positive or negative factors and give the indication for further research and action. Model evaluation is also a vital tool for evaluating a given problem or theories in order to know how to overcome it or in what way will you contribute.

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