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BIOSTATISTICAL ANALYSIS OF BIRTH WEIGHT AND HEAD CIRCUMFERENCE OF BABIES A CASE STUDY OF NIGERIA

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ABSTRACT

This paper examined the relationship between birth weight and head circumference of babies. The ordinary least square method of linear regression analysis and Chi-square test were utilized to achieve its objectives. The hypothesis that birth weight is independent of head circumference; birth weight is independent of sex; and head circumference is independent of sex was rejected at 5 percent level of significance. The result showed that birth weight is dependent on head circumference and sex; and that head circumference depends on sex. Birth weight and head circumference of male babies are higher than that of the female babies. However, female have normal head circumference than male. Moreso, a significant linear positive relationship exists between birth weight and head circumference.

INTRODUCTION

Birth weight is a reliable outcome measure of the quality of pregnancy; it is the most important indicator of maturity of the neonate and health status of the mother. It is also an important determinant of prenatal mortality, it is known to increase with successive birth order up to the fourth or fifth rank in other words, and babies tend to outweigh their immediate elder siblings.

The birth weight of a newborn infant is influenced by various factors including material, environmental and genetic factors. Low birth weight (i.e. less than 2.5kg) increases prenatal mortality for reasons ranging from prematurity, to placental sufficient. On the other hand, macrosomia or high birth weight (more than 4.0kg) leads to obstetric complication arising from difficult delivery and subsequent birth trauma including birth asyphylxia (lack of oxygen causing death or loss of consciousness). It is therefore necessary to know the normal birth weight range in any geographical area so that these problems can be anticipated. Figures obtained from western and northern part of the country varied from one area to the other. This may be an indicator that birth weight may vary from one ethnic group to the other. Each newborn is carefully checked at birth for signs of problem or complications and a complete physical assessment will be performed that includes everybody system. Throughout the hospital stay, nurses and other health providers continually assess a body for changes. In health and for signs of problems or illness, one of the assessments is Birth weight Measurement of the occipital; frontal circumference known as the head circumference. Gestation period last for nine (9 months and it has been found that the average weight of a term baby is about 3.2kg. In general, small babies and very big babies are at greater risk. Weight is measured in kilograms. The head circumference commonly known as occipital frontal circumference is usually measured with flexible tape or ultrasonographically. It is the measurement of the child's head at its largest area above the eyebrows and ear, around the back of the head. The normal fetal head circumference at term ranges between 32-38cm and there are abnormal sizes which could be smaller or bigger than the normal. The entire situation may be because of one problem or the other or rather hereditary. Occipital frontal circumference (OFC) is measured in centimeter. Babies born with small head circumference could be traced to have a problem from their mother habit or environmental factors and babies born with larger head circumference could be said to have some of the head diseases including Hydrocephalus; Benighn familial macrolephaly, intracracranial bleeding, morquio syndrome, hurler syndrome, canavan disease etc. These diseases can be traced to be caused by maternal feeding habit and drug addicted mother. As the child grows, it is advisable to cheek up the head size. A deviation from the expected normal head growth may alert the doctor of a possible problem during the well-baby examination. For instance, according to Geoffrey (1988) a head that is larger than normal (32-38cm) or whose size is increasing faster than normal maybe an indication of increased intracranial pressure. The problem is caused by multiple causes including head injury, meningitis, Water in the brain or bleeding within the skull. Also, an exceptionally small head size called Microcephaly or very slow growth rate may indicate that the brain is not developing properly. Moreover, autism could be predicted by head size. Autism is a serious mental condition that develops during childhood in which one becomes unable to communicate or form relationship with other. Health is a multi-dimensional concept who proposed the following definition? "A state of complete physical mental and social well-being and not merely the absence of infirmities" following its appearance in the preamble of the 1948 WHO constitution, this concept has often been hailed for its comprehensiveness and its emphasis on the

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broader positive and psycho-social aspects of health beyond the traditional biomedical negative aspects such as death, disease and disability (Young, 1988). Health is therefore seen as a resource for everyday life not the objective of living. It is a positive concept emphasizing social and personal resources as well as physical capacities. Based on the definitions, Young developed his own multi-dimensional classification scheme of the components of the health status. He identified four domains; Opportunity, Perceptions Functional status and Impairment, respectively each domain is further disaggregated into sub-domain. The functional status domain comprises the Social Psychological and Physical sub domain. It is clear from this classification that even within the broader health issues, more linked to quality of life (participation in the community, interaction with others, happiness etc. The above definitions and classifications schemes concerns health in general. They are not specific to child health, but in the case of child health, a multi-dimensional approach is required.

The management of ill health has prompted medical practitioners and researchers to delve deeper into several researches which reveals most of the causes of ill health. In search of some of these causes of ill-health, prompted the researcher to look into the birth weight and head circumference of babies. This work wants to find out if most of the deformities and sickness that leads to high infant mortality rate and other psychologically problems could be attributed to the weight and to the head circumference at birth. If yes, then what could be the possible factors responsible for abnormal sizes in both, what are some of the disabilities, ill health that are more pronounced among children born over or under sized?

SIGNIFICANCE OF STUDY

Health is wealth; it is only a healthy person that talks or thinks of acquiring wealth, firm etc. This work helps us know the importance of measuring especially baby's weight and their head circumference when conceived. Medical data have shown that adults with over or under weights are associated with one ill health or the other, for instance, an over weighted adult is liable to sickness such as early hypertension, obesity and some other diseases they catch easily. It then becomes very important to study the weight of newly born infants. This will help parents during pregnancy to check their baby's weight with the help of a medical practitioner so that these babies will not run the risk of developing some kinds of ill health or deformities associated with very low or very high weights.

1.3 OBJECTIVES

1. To fit a linear regression model of the data under study
2. Determining the nature of birth weight and head circumference of babies.
3. To check the effect of data under study.

1.4 HYPOTHESIS

H_0: Birth weight is independent of head circumference
H_1: Birth weight is not independent of head circumference
H_0: Birth weight is independent of sex
H_1: Birth weight is not independent of sex
H_0: Head circumference is independent of sex
H_1: head circumference is not independent of sex
H_0: $\beta = 0$
H_1: $\beta \neq 0$

1.5 DEFINITION OF BASIC TERMS

Full Term babies:- These are babies born between 37 weeks and 41 weeks of gestation, they are about 3.2kg in weight, Barbara (2003).
Preterm Babies:- These are babies born before 37 weeks of gestation, they are about 1.5kg - 2.5kg in weight.
Neonate:- This is another name for newly born babies.
Gestation:- This is the process of carrying a baby inside the mother's womb.
Fetal:- This baby has developed to certain stage within its mother's womb before birth.

1.6 MATERNAL WEIGHT GAIN

According to Wildsehet (2001), in well nourished communities, the average maternal weight gain during pregnancy is 10-12.5kg during the first quarter of pregnancy the average weight gain is 0.6kg although many women show changes of even lose weight. The maximum rate of weight gain is from 17-24 weeks and by mid pregnancy the total weight gain is about 3.5-4.0 kg.

Also according to Derek, in the second half of pregnancy, there is an average gain of 0.4-0.5kg/week with a slight fall in the last quarter; considerable individual variation occurs, depending on age, initial weight, cigarette smoking dietary habits and professional advice.

1.7 VERY LOW BIRTH WEIGHT

Very low birth weight is a term used to describe babies who are born weighing less than 1.5kg. Babies with very low weight look very much smaller than other babies of normal birth weight. A very low birth weight baby's head appears to be bigger than the rest of the body and him/her often looked extremely thin with little body fat. The skin is often quite transparent, allowing the blood vessels to be seen easily.

The question now is what is the cause of this very low birth weight? It was found that the primary cause of very low birth weight (VLB) is premature birth (i.e. born before 37 weeks gestation). Very low birth weight babies are often born before 30 weeks of pregnancy. This simply means that a baby has less time in the mother's uterus to grow and gain weight since much of a baby's weight is gained during the later part of pregnancy.

Another cause of VLBW is intrauterine growth resection (IUGR). This is when a baby does not grow well during pregnancy because of problems with placenta, the mother's health, or birth defects. Most VLBW babies who have IUGR are also born early and are both very small and physically immature. Any baby born prematurely is more likely to be small. However, there are other factors that can also contribute to the risk of VLBW they include;

Age:- Mothers younger than 15 years old are at higher risk of conceiving babies with VLBW

Multiple Birth:- About 10% of twins ad 1/3 of triplets have VLBW so they are at increased risk.

Mothers health:- Women who are exposed to drugs, alcohol and cigarettes during pregnancy are more likely to have low or very low birth weight babies. Mothers of lower socio-economic status are also more likely to have poorer nutrition, inadequate prenatal care and pregnancy complications. These factors can contribute to VLBW.

1.8 VERY LOW BIRTH WEIGHT A CONCERN

VLBW baby is often at increased risk for complications. The baby's tiny body is not as strong and he/she may have a harder time eating, gaining weight and fighting infection, because they have so little body fat. VLBW babies often have difficulty staying warm in normal temperatures, because most babies with VLBW are premature, it can be difficult to separate the problems due to the prematurity from the problems of just being tiny. The following are some of the common problems of VLBW babies: Low oxygen levels at birth; inability to maintain body temperature; difficult feeding and gaining weight; major surgery shortly after birth e.t.c. Children with Down's syndrome also have a higher than average incidence of ACUTE LYMPHOCYTIC LEUKEMIA (ALL), Coall and Chishoim (2003).

2.0 METHODOLOGY

The method used in this work is ordinary least square method inform of linear regression and chi-square analysis.

Regression shall be used to know the linear relationship between birth weight (Y) and circumference (X). Chi-square test shall be used to know the dependency of birth weight on head circumference and their individual dependence on sex.

2.2 PRESENTATION OF DATA

Birth Weight	
Very low birth weight	0.4 - 1.4kg
Low birth weight	1.5 - 2.4kg
Normal birth weight Normal birth weight	2.5 - 4.0 kg
High birth weight	4.1 and above

Source: Federal medical center FMC, Umuahia Abia state.

Head Circumference	
Very small head circumference	10 – 19cm
Small head circumference	20 – 31cm
Normal head circumference	32 – 38cm
Big head circumference	39cm above

Source: Federal medical center FMC, Umuahia Abia state.

	Head circumference			
Birth weight	**Very small**	**Small**	**Normal**	**High**
Very low	3	13	3	-
Low	-	13	67	3
Normal	-	16	1010	12
High	-	1	85	40

Source: Federal medical center FMC, Umuahia Abia state.

Birth weight	Sex Male	Female
Very low	11	8
Low	36	56
Normal	555	515
High	46	39

Source: Federal medical center FMC, Umuahia Abia state.

Head circumference	Sex Male	Female
Very low	2	1
Low	34	33
Normal	534	620
High	27	15

Source: Federal medical center FMC, Umuahia Abia state.

2.1 LINEAR REGRESSION AND ANOVA

2.1.1 ESTIMATION OF PARAMETER

Let the parameter β_0 and β_1 be estimated respectively from the data using the method of ordinary least square. The regression equation is written as

$Y = \beta_0 + \beta_1 X_1 + \varepsilon$

where, Y = Birth weight, β_0 = constant, β_1 = Parameter X_1 = Head circumference, ε = error term

Making e subject of formula

$\varepsilon = (Y- \beta_0 - B_1X_1)$

Squaring and summing both sides

$\Sigma \varepsilon^2 = \Sigma(Y-\beta_0 - \beta_1 X_1)^2$

Let $\Sigma \varepsilon^2 = S$

$S = \Sigma(Y- \beta_0 - \beta_1 X_1)^2$

Differentiating with respect to β_0 & β_1 we obtain

$\frac{\delta S}{\delta \beta_0} = -2\Sigma (Y- \beta_0 - \beta_1 X_1) = 0$ ……………………(1)

$\frac{\delta S}{\delta \beta_1} = -2X_1\Sigma(Y-\beta_0 - \beta_1X_1) = 0$ ……………………(2)

Divide both equation (1) & (2) by -2, we have

$\Sigma (Y-\beta_0 - \beta_1 X_1) = 0$

$X_1\Sigma (Y - \beta_0 - \beta_1x_1) =0$

Then, we have the normal equations as

$\Sigma Y = n\beta_0 + \beta_1 \Sigma X_1$ ………………………………. (3)

$\Sigma X_1Y = \beta_0\Sigma X_1 + \beta_1\Sigma X_1^2$ ………………………… (4)

where, the constants β_0 and β_1 are determined by solving above equation simultaneously.

$$\hat{\beta} = \frac{\sum Y \sum X^2 - \left(\sum X\right)\left(\sum XY\right)}{n\sum X^2 - \left(\sum X\right)^2} \quad \text{……………………..(5)}$$

$$\hat{\beta}_1 = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum X^2 - \left(\sum X\right)^2} \quad \text{……………………. .(6)}$$

Equation 5 & 6 can also be written as

$$\beta_0 = \overline{Y} - \beta_1\overline{X} \quad \text{………………………………………(7)}$$

$$\beta_1 = \frac{\left(\sum X - \bar{X}\right)\left(\sum Y - \bar{Y}\right)}{\sum (X - \bar{X})^2} = \frac{COV(XY)}{VarX} = \frac{S_{xy}}{S_x^2} \quad \text{..........(8)}$$

2.1.2 TEST FOR SIGNIFICANCE FOR REGRESION ANALYSIS

The test is used to check if a linear statistical relationship exists between the dependent variable (Y) and independent variable (X). The statement of hypothesis is;

$H_0 : \beta_0 = \beta_1 = 0$

$H_1 : \beta_0 = \beta_1 \neq 0$

Decision is to reject H_0 if the F distribution with K degrees of freedom in the numerator and (n-k-1) degrees of freedom in the denominator is lesser than the calculated statistic, that is $F_0 > F_2$, k, n –k-1 otherwise accept H_o.

F-statistic computation

The total sum of square (SST) SST = $\sum\sum Y_{ij}^2 - [\sum\sum Y_{ij}]^2/nk$

Regression sum of square SSR = $[\sum Y_i^2/n_i] - [\sum\sum Y_{ij}/kn]^2$

Error sum of squares SSE = $\sum\sum Y_{ij}^2 - [\sum y_{i.}^2/ n_i]$

Table: ANOVA Table

Source of variation	Sum of squares	Degree of freedom	Mean sum of square	F-calculated
Regression	$[\sum Y_i^2/n_i] - [\sum\sum Y_{ij}]^2/nk$	k-1	SSR / k-1	MSR / MSE
Error	$\sum\sum Y_{ij}^2 - [\sum y_{i.}^2/ n_i]$	n-k-1	SSE / n-k-1	
Total	$\sum\sum Y^2 - [\sum\sum Y_{ij}]^2/nk$	n-1		

where n = number of observations and K = number of estimating parameter

2.1.3 COEFFICIENT OF DETERMINATION (R^2)

The coefficient of determination is the proportion of the viable in the dependent variable explained by the regression model, and is a measure of the goodness of fit of the model. It range from 0 and 1 and is calculated as follows.

$$R^2 = \frac{SST - SSE}{SST} = 1 - \frac{SSE}{SST} = \frac{SSR}{SST}$$

2.2 CHI-SQUARE

Chi-square is a measure of the discrepancy existing between the observed and expected frequencies.

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \quad \text{and} \quad E_i = \frac{C_T \times R_T}{N}$$, Adebile (2003)

where,

O_i = observed frequency, E_i = expected frequency

C_T = column total, R_T = row total and N = number of observations

2.2.1 TEST FOR SIGNIFICANCE OF χ^2

This test is used to know the dependency of birth weight on head circumference and their individual dependence on sex.

In practice, expected frequencies are computed on the basis of a hypothesis H_0: if H_0 under this hypothesis, the computed value of χ^2 is greater than critical value, then we reject H_0 otherwise accept H_0 against the alternative H_1.

2.2.2 COEFFICIENT OF CONTIGENCY

A measure of the degree of relationship, association, or dependence of the classifications in a contingency table is given by

$$C = \sqrt{\frac{\chi^2}{\chi^2 + N}}$$

The larger the value of C, the greater is the degree association, the number of rows and columns in the contingency. Table determines the maximum value of C, which is never greater than 1. If the number of rows and columns of a contingency table is equal to K, the maximum value of C, given by $\sqrt{\frac{k-1}{k}}$

3.0 RESULT

3.1 DATA ANALYSIS

3.1.1 CHI-SQUARE (X^2) test

H_0: Birth weight its independent of head circumference
H_1: Birth weight is not independent of head circumference

Birth weight	**Head circumference**				
	Very small	**Small**	**Normal**	**High**	**Total**
Very low	3(0.045)	13(0.645)	3(17.484)	- (0.825)	19
Low	-(0.197)	13(2.819)	67(76.378)	3(3.606)	83
Normal	-(2.459)	16(35.256)	1010(955.189)	12(45.095)	1038
High	-(0.299)	1(4.279)	85(115.948)	40(5.474)	126
Total	3	43	1165	55	1266

The values in parenthesis are the expected frequencies.

χ^2 = **750.995**

At 5% level of significance χ^2 tab. = χ^2 0.05,9 = 16.919, and χ^2 cal. = 750.995

Since χ^2 cal > χ^2 tab, we reject H_0 and hence conclude the birth weight is not independent on head circumference.

H_0: Birth weight is independent of sex
H_1: Birth weight is not independent of sex

Birth weight	**Sex**		
	Male	**Female**	**Total**
Very low	11(9.7251)	8(9.2749)	19
Low	36(47.0900)	56(44.9099)	92
Normal	555(547.6779)	515(522.3223)	1070
High	46(43.5071)	39(41.4929)	85
Total	648	618	1266

The values in parenthesis are the expected frequencies.

χ^2 = **6.1858**

At 95% level of significance χ^2 tab. = X^2 0.95,3 = 0.352 and χ^2 cal. = 6.1858

Hence, we conclude that birth weight is not independent on sex since χ^2 cal > χ^2 tab.

H_0: Head circumference is independent of sex
H_1: Head circumference is not independent of sex

Head circumference	**Sex** **Male**	**Female**	**Total**
Very low	2(1.4147)	1(1.5853)	3
Low	34(31.5948)	33(35.4052)	67
Normal	534(544.1848)	620(609.8152)	1154
High	27(19.8057)	15(22.1943)	42
Total	597	699	1266

The values in parenthesis are the expected frequencies.

χ^2 = **6.1108**

At 95% level of significance χ^2 tab. = $\chi^2_{0.95,3}$ = 0.352

Since χ^2 cal > χ^2 tab, we reject H_0 and conclude that head circumference is not independent on sex.

3.1.2 REGRESSION ANALYSIS

Y = a + bX

$$a = \frac{\sum Y \sum X^2 - \left(\sum X\right)\left(\sum XY\right)}{n\sum X^2 - \left(\sum X\right)^2}$$

$$b = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum X^2 - \left(\sum X\right)^2}$$

From the computed result;

Y = 17.9 + 0.895X

Testing for β

$H_o = \beta = 0$

$H_1 = \beta \neq 0$

Since σ_e^2 population variance is unknown, it is estimated by S^2 (sample variance)

$$S^2 = \frac{(n-1)(S_y^2 - b^2 S_x^2)}{n-2}$$

$$S_y^2 = \frac{\left(\sum Y - \bar{Y}\right)^2}{n}$$

$$S_X^2 = \frac{\left(\sum X - \bar{X}\right)^2}{n}$$

Test statistics

$$t_{cal} = \frac{b-\beta}{S/\sqrt{n-1}}$$

Substituting,

$$S_X^2 = \frac{13418 - (3.1953)^2}{1266}$$

$= 0.3894$

$$S_Y^2 = \frac{1566563.09 - (35.05242)^2}{1266}$$

$=8.7409$

Therefore,

$$S^2 = \frac{(1266-1)(8.7409-(0.895)^2 (0.3894)}{(1266 -2)}$$

$S^2 = 6.9908$
$S = 2.644$

$$t = \frac{(0.895-0)\times\sqrt{1266-1}}{2.644} = 17.7953$$

At 5% level of significance $t_{0.025,\ 1264} = 1.960$
Since 17.7953 > 1.960, we reject H_0 and conclude that there is a linear relationship between X and Y.

SUMMARY/CONCLUSION

From the data analysis, the result of the first hypothesis shows that birth weight is not independent of head circumference that is to say, that birth weight is dependent on head circumference. Hypothesis two and three depicts that birth weight and head circumference depends on gender. In table 1.1 and 1.2 respectively, the male sex has the greater number of very low, normal and high birth weight and also greater number of very small, small and large circumference. The fourth hypothesis shows a linear relationship between the birth weight and head circumference. The regression equation was found to be Y= 17.7 + 0.895X
With the result of the analysis, I will make the following conclusions. Birth weight is not independent of head circumference. Birth weight and head circumference are not independent on sex. Birth weight and head circumference of male babies are higher than that of female babies. The females have normal head circumference than male.
There is a linear relationship between the weight and head circumference of babies.

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