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Obaji Ifeoma
Department of Mathematics and Statistics, Ignatius Ajuru University of Education Rivers State P.M.B. 5047, Port Harcourt, Rivers Nigeria

Nwagor Peters
Department of Mathematics and Statistics, Ignatius Ajuru University of Education Rivers State P.M.B. 5047, Port Harcourt, Rivers Nigeria

Corresponding Author:
Obaji Ifeoma
Department of Mathematics and Statistics, Ignatius Ajuru University of Education Rivers State P.M.B. 5047, Port Harcourt, Rivers Nigeria

Modelling the effect of age, previous birth and hemoglobin level of mothers on birth weights

Obaji Ifeoma and Nwagor Peters

Abstract
The study was aimed at using multiple regression technique to analyze the relationship between Birth Weight and mother's age, previous birth & hemoglobin level of mothers in Imo State; a case study of Aboh Mbaise General Hospital. The analysis showed that there is no multicollinearity, autocorrelation which agrees with the assumptions of multiple linear regression. The analysis shows that heteroscedasticity exists in the data. The error term followed a normal distribution using Kolmogorov-Smirnov. The analysis showed there is significant relationship between birth weight and previous number of births, age of mothers & the hemoglobin level of mothers. Further analysis based on the individual test shows that age of mothers contributes positively to birth weight, while previous number of births and hemoglobin level of mothers do not contribute to birth weight. The R^2 is 52.6% which entails that 52.6% variation in the value of birth weight is explained by a change in independent variables. The study concluded that age of mothers is a predictor of weight of babies, and recommended among others that similar work be carried out using other mothers' characteristics such as weight, state of health and hereditary factors.

Keywords: age of mothers, previous birth, birth weight, hemoglobin level, heteroscedasticity, autocorrelation, multicolinearity

Introduction

Child bearing is regarded as a vital and necessary activity in the world today; this is why people come together for marriage not only to live together; but also to produce a generation of children. Thus, to maintain a continuum in any generation, new beings must be born.

When a woman conceives, she visits the hospitals, clinics or maternity for ante-natal care. In every birth, there must be stress and complications involve in it. This stress and complications that is involved can be reduced if the mother is serious with her ante-natal care treatment. Failure to be serious with her ante-natal care treatment which helps in easing labour pains may lead to hard labour and complications which can cause death of the mother and the baby as well. During ante-natal visit in which the pregnancy is confirmed, the physician makes a thorough examination and also learns the woman's medical history.

The pelvic size and space enclosed by the bones of the pelvic is estimated by the physician if it is her first pregnancy. A small pelvic may mean a difficult birth in that a full term baby may not be able to pass easily through the birth canal. Also, just before delivery, the mother's Blood Pressure (B.P.), heamoglobin level etc are checked to see if she can really cope with the stress of labour (Pojda & Kelley, 2009) [8]. At the end of nine months or more she gives birth to a new human being.

After birth in the hospital ward, clinic or maternity, the baby's weight is measured and recorded immediately after delivery. According to Nwamkpa (1997) [6], a baby's weight should fall between 2.5kg and 4.5kg and any birth weight outside this range is regarded as underweight as the case may be.

According to Pojda & Kielly (2009) [8], evidence now shows that adults born with low birth weights face an increased risk of chronic diseases, such as high blood pressure, stroke, coronomy heart disease, blindness, deafness, stroke in adulthood, etc. However, high birth weight or macrosomia (4.0kg – 5.9kg), is not usually a cause for concern, except some babies who are born large at gestational age (i.e. excessive growth in the womb).

Birth weight is known to be affected by quite a number of factors such as environmental, socio-economic, biological factors etc. However, biological factors are seen as the most significant factors that determine birth weight because it is hereditary.

Gestational period below 37 week is associated with premature birth and the risk of low birth weight except for mothers who are diabetic (which is the most common cause of large gestational age). Also, increased blood sugar in the mother will cause the baby to produce extra insulin which can lead to excessive growth in the womb (Pojda & Kielly, 2009) [8].

According to Oni (1986) [7], the gender of a child is imperative since male babies are generally higher than female counterpart. Previous pregnancy or birth, parity (gravida) is defined as the number of time a woman has given birth before a given birth. Also, past child bearing experience has an important role to play in predicting the likely outcome of the present pregnancy. After the fifth pregnancy, a woman is most likely to have a low birth weight due to the size of the family, socio-economic status, lack of education.

Statement of Problem

Medically, it is believed that numerous mothers' characteristics such as mother's age, number of previous pregnancy and hemoglobin concentration level contribute to the weight of new babies. It is in this regard that this study is necessary to investigate if mothers' age, number of previous pregnancy and hemoglobin concentration plays a part in weights of babies. Data set collected from Government owned hospital (Aboh Mbaise General Hospital, Imo State) is employed to examine the assertion.

Review of Related Literatures

A lot of research has been carried out in the past regarding to the factors that affect birth weight or related works that dealt on regression analysis techniques. A few of these are mentioned here for the purpose of giving taste to this present academic work.

Safithri *et al* (2019) [9] carried out a research on the relationship between hemoglobin level and weight of babies using all women that were pregnant in rural areas for the period of three months who were registered in a hospital. The regression correlation technique was employed. The result of the study showed that there was not significant correlation between hemoglobin level and weight of babies at 5% level of significance. The study recommended the addition of other indicators of low hemoglobin level by subsequent studies.

Anand & Jo (2015) [1] carried out a research on hemoglobin level and weight of babies, with other indicators of weight of babies. The regression correlation technique was employed. About 33 other studies were examined in the study. The result of the study showed that there was a relationship between hemoglobin level and weight of babies. The result also showed that anemia contributed significantly as a cause risk of low weight of babies. The study recommended that hemoglobin level should be often checked, especially during pregnancy.

Atuahene *et al* (2015) [2] worked on indicators of weight of babies in Accra region of Ghana. The result of the analysis showed that babies with low weight had significant relationship with low gestation at birth. The result also showed that diastolic blood pressure and gestation contributed significantly as indicators of weight of babies. Najeeba *et al* (2015) [4] researched on the impact of Maternal Anem on Hemoglobin level and Birth weight of Newborn. The research focused on fifty pregnant women who were in labour in a registered hospital for the period of six months. The result of the study showed that hemoglobin (cord blood) figures reduced so far the hemoglobin level minimizes for the mothers. They researchers concluded maternal anemia is too severe to affect the health fetal.

Having reviewed these past works, the present study shall look into how to use multiple linear regression as a statistical technique to study the effect of age, previous birth and hemoglobin level of mothers on birth weights of babies in Imo State.

Methodology

Regression Models

A factual method that communicates numerically the affiliation between two or more quantitative variables in such a way that the response variable can be anticipated from the informative factors is known as Regression analysis. It can be utilized to see at the impacts that some variables apply on others. It may be direct or non-linear. In the case where the independent variable exceeds one, it becomes the multiple regression (Inyama & Iheagwam; 2006) [3] with its basic model as:

Considering a linear regression model (multiple) as in Equation (1);

$$Y_i = \lambda_0 + \lambda_1 Z_1 + \cdots + \lambda_p Z_{pi} + e_i \quad \ldots (1)$$

Even though, there are three explanatory variables in the data for this study, for the case of easier computation, only two explanatory variables shall be used to demonstrate the regression model in multiple form [See Equation (2)].

$$Y_i = \lambda_0 + \lambda_1 Z_{1i} + \lambda_2 Z_{2i} + e_i \quad \ldots (2)$$

$Y \Rightarrow$ Response variable,

Z_1 & $Z_2 \Rightarrow$ Explanatory variables,

$e_i \Rightarrow$ Error term, and

$i \Rightarrow$ ith observation

If Y, Z_1 & Z_2 are in deviation forms, then Equation (2) is now written as shown in Equation (3)

$$y_i = \lambda_1 z_{1i} + \lambda_2 z_{2i} + e_i \quad \text{… (3)}$$

Where

$y_i = Y_i - \overline{Y}$, $z_{1i} = Z_{1i} - \overline{Z}_{1i}$ and $z_{2i} = Z_{2i} - \overline{Z}_{2i}$

$$e_i = y_i - \hat{y}_i = y_i - \hat{\lambda}_1 z_{1i} - \hat{\lambda}_2 z_{2i} \quad \text{… (4)}$$

$$\Sigma e_i^2 = \Sigma(y_i - \hat{\lambda}_1 z_{1i} - \hat{\lambda}_2 z_{2i})^2 \quad \text{… (5)}$$

The estimate of the parameters using OLS technique is shown in Equations (6), (7) & (8)

$$\hat{\lambda}_1 = \frac{\Sigma z_1 y \Sigma z_2^2 - \Sigma z_1 z_2 \Sigma z_2 y}{\Sigma z_1^2 \Sigma z_2^2 - (\Sigma z_1 z_2)^2} \quad \text{… (6)}$$

$$\hat{\lambda}_2 = \frac{\Sigma z_1^2 \Sigma z_2 y - \Sigma z_1 z_2 \Sigma z_1 y}{\Sigma z_1^2 \Sigma z_2^2 - (\Sigma z_1 z_2)^2} \quad \text{… (7)}$$

and

$$\hat{\lambda}_0 = \overline{Y} - \hat{\lambda}_1 \overline{Z}_1 - \hat{\lambda}_2 \overline{Z}_2 \quad \text{… (8)}$$

The following formulas are used to obtain the sum of squares and cross products in deviation forms.

$$\Sigma z_1^2 = \Sigma(Z_1 - \overline{Z}_1)^2 = \Sigma Z_1^2 - \frac{(\Sigma Z_1)^2}{n} \quad \text{… (9)}$$

$$\Sigma y^2 = \Sigma(Y - \overline{Y})^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{n} \quad \text{… (10)}$$

$$\Sigma z_2^2 = \Sigma(Z_2 - \overline{Z}_2)^2 = \Sigma Z_2^2 - \frac{(\Sigma Z_2)^2}{n} \quad \text{… (11)}$$

$$\Sigma z_1 z_2 = \Sigma(Z_1 - \overline{Z})(Z_2 - \overline{Z}) = \Sigma Z_1 Z_2 - \frac{\Sigma Z_1 \Sigma Z_2}{n} \quad \text{… (12)}$$

$$\Sigma z_1 y = \Sigma(Z_1 - \overline{Z}_1)(Y - \overline{Y}) = \Sigma Z_1 Y - \frac{\Sigma Z_1 \Sigma Y}{n} \quad \text{… (13)}$$

$$\Sigma z_2 y = \Sigma(Z_2 - \overline{Z}_2)(Y - \overline{Y}) = \Sigma Z_2 Y - \frac{\Sigma Z_2 \Sigma Y}{n} \quad \text{… (14)}$$

Coefficient of Determination

$$R^2 = \frac{\hat{\lambda}_1 \Sigma z_1 y + \hat{\lambda}_2 \Sigma z_2 y}{\Sigma y^2} \quad \text{… (15)}$$

The adjusted R^2 is stated in Equation (16)

$$\overline{R}^2 = t\frac{n-1}{n-p} \quad \text{… (16)}$$

Where $t = 1-(1-R^2)$

Table I: Analysis of Variance Table

SV	DF	SS	MS
Regression	2	SS_R	MS_R
Error	n – 3	SS_E	MS_E
Total	n – 1	SS_T	

$$F_{cal} = \frac{MS_R}{MS_E} \quad \dots (17)$$

$$SS_T = \Sigma y_i^2 \quad \dots (18)$$

$$SS_R = \hat{\lambda}_1 \Sigma z_1 y + \hat{\lambda}_2 \Sigma z_2 y \quad \dots (19)$$

$$SS_E = SS_T - SS_R \quad \dots (20)$$

Multicolinearity Tests

The condition number with the condition index CI is stated in Equations (21) & (22) respectively as:

$$K = \frac{Maximum\ Eigen - value}{Minimum\ Eigen - value} \quad \dots (21)$$

And

$$CI = \sqrt{K} \quad \dots (22)$$

If 10 ≤ CI ≤ 30, there is moderate to strong multicollinearity
If CI > 30, there is severe multicollinearity
If CI < 10, there is no significant multicollinearity

Autocorrelation Test

The Durbin-Watson test is utilized to test for the nearness of autocorrelation which is given by $D = \frac{\sum (e_i - e_{i-1})^2}{\sum e_i^2}$ …(23)

where e_i is OLS residual

Hypotheses

$H_0 : \rho = 0$ (no autocorrelation)
$H_1 : \rho \neq 0$ (presence of autocorrelation)
Reject H_0 if $D > 4 - D_L$
Accept H_0 if $D < 4 – D_u$, and it is not conclusive if D lies between
$4 – D_u$ and $4 – D_L$

Heteroscedasticity Test via White Test

- Reject H_0 that there is absence of heteroscedasticity if

$$\chi^2_{cal} = nR^2 > \chi^2_{tab} \quad \dots (24)$$

And do not reject H_0 otherwise.

Data Analysis

The technique for data collection used is the registration method. Data were obtained from Aboh Mbaise General Hospital in Imo State on the weight of babies, Age of mother, H.B. level of mother, previous number of pregnancy etc. The data collected for this study are presented in Table a.

Table a: Data on Weight(Y), Age (Z_1), Previous Birth (Z_2) and Hemoglobin level of mothers (Z_3).

S/N	Y	X1	X2	X3	S/N	Y	X1	X2	X3
1	3.4	32	4	6.2	51	3.9	38	1	10.3
2	2.7	24	5	5.4	52	3.3	35	0	8.9
3	2.4	21	0	6.9	53	3.1	30	3	9.7
4	2.9	25	1	14	54	3.0	27	9	7.4
5	3.5	32	6	13.1	55	3.6	30	1	9.5
6	3.7	34	6	8.6	56	3.2	28	3	8.4
7	2.9	29	5	10.9	57	2.4	22	2	5.7

8	3.3	31	6	7	58	3.5	35	0	14.7
9	4.1	33	1	8.3	59	2.6	26	6	13
10	3.5	26	3	12.8	60	4.1	36	0	10.1
11	3.3	23	1	14	61	2.9	31	0	7.3
12	3.5	33	1	9.2	62	3.5	38	5	6.3
13	3.0	32	2	9.2	63	2.7	30	7	9.5
14	3.2	34	0	6.2	64	2.5	27	3	12.3
15	3.5	37	3	13.9	65	3.3	31	4	10.9
16	3.9	38	2	6.5	66	3.0	25	0	9.9
17	3.3	35	3	5.5	67	2.9	23	6	10.8
18	3.1	30	0	11.2	68	3.5	27	1	13.5
19	3.0	27	0	6.7	69	3.7	35	4	13.3
20	3.6	30	2	7.3	70	3.3	30	1	7.9
21	3.2	28	1	10.8	71	3.4	32	0	9.9
22	2.4	22	4	8.1	72	2.7	24	0	10.7
23	3.5	35	4	8.6	73	2.4	21	2	7.7
24	2.6	26	1	8	74	2.9	25	0	7.9
25	4.1	36	6	5.5	75	3.5	32	1	8.9
26	3.0	32	5	10.5	76	3.7	34	0	9.4
27	3.5	38	5	10.1	77	2.9	29	2	5.7
28	2.7	30	0	10.1	78	3.3	31	4	14.7
29	2.5	27	0	8.9	79	4.1	33	2	5.7
30	3.3	31	3	9.7	80	3.5	26	4	14.7
31	3.0	25	8	7.4	81	3.3	23	5	14.6
32	2.9	23	4	9.4	82	3.5	33	4	14.7
33	3.5	27	3	8.4	83	3.0	32	5	15.3
34	3.7	35	2	5.7	84	3.2	34	6	14.7
35	3.3	30	0	14.7	85	3.5	37	5	10.8
36	3.4	32	4	13.4	86	3.9	38	4	11.7
37	2.7	24	0	10.1	87	3.3	35	0	10.1
38	2.4	21	0	7.3	88	3.1	30	0	8.9
39	2.9	25	5	6.3	89	3.0	27	3	9.7
40	3.5	32	7	9.5	90	3.6	30	9	7.4
41	3.7	34	3	12.3	91	3.2	28	1	9.4
42	2.9	29	4	10.9	92	2.4	22	3	8.4
43	3.3	31	0	9.9	93	3.5	35	2	5.7
44	4.1	33	6	10.8	94	2.6	26	0	14.7
45	3.5	26	1	13.5	95	4.1	36	6	13
46	3.3	23	4	13.3	96	2.9	31	0	10.1
47	3.5	33	1	7.9	97	3.5	38	0	7.3
48	3.0	32	0	9.9	98	2.7	30	5	6.3
49	3.2	34	0	10.7	99	2.5	27	7	9.5
50	3.5	37	2	7.7	100	3.3	31	3	12.3

Table b: SPSS Printout

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics		
		B	Std. Error	Beta			Zero-order	Tolerance	VIF
1	(Constant)	.973	.236		4.125	.000			
	Age	.068	.007	.716	10.177	.000	.714	.999	1.001
	Previous Birth	.011	.013	.061	.870	.386	.082	.998	1.002
	Hemoglobin Level	.018	.011	.109	1.554	.124	.092	.998	1.002
a. Dependent Variable: Birth Weight									

However, from Table b, the SPSS printout shows that
Birth Weight = 0.973 + 0.068Age + 0.011 Previous Birth + 0.018 Hemoglobin Level

Joint Test

H_0: There is no relationship between birth weights and previous number of births, age of mothers & the hemoglobin level of mothers.

H_1: Relationship exists.

Table c: SPSS Printout

ANOVA[b]						
Model		SS	df	MS	F	Sig
1	Regression	10.124	3	3.375	35.528	.000[a]
	Residual	9.119	96	.095		
	Total	19.242	99			
a. Predictors: (Constant), Hemoglobin Level, Age, Previous Birth						
b. Dependent Variable: Birth Weight						

The H_0 is rejected since the p-value (0.000) is lesser than 5% level of significance. It is necessary to investigate an individual test to know the effect of previous number of births, age of mothers & the hemoglobin level of mothers on birth weight.

Individual Test

From Table b, the SPSS printout shows that T-calculated for λ_1 = 10.177, λ_2 = 0.870 and λ_3 = 1.554.

SE (λ_1) = 0.007, SE (λ_2) = 0.013 and SE (λ_3) = 0.011

Hypotheses

$H_0^1 : \hat{\lambda}_1 = 0$ (There is no relationship between birth weights and previous number of births).

$H_1^1 : \hat{\lambda}_1 \neq 0$ (Relationship exists)

$H_0^2 : \hat{\lambda}_2 = 0$ (There is no relationship between birth weights and age of mothers).

$H_1^2 : \hat{\lambda}_2 \neq 0$ (Relationship exists)

$H_0^3 : \hat{\lambda}_3 = 0$ (There is no relationship between birth weights and hemoglobin level of mothers).

$H_1^3 : \hat{\lambda}_3 \neq 0$ (Relationship exists)

Since p-value for age of mothers (0.000) is less than the level of significance (0.05), we reject H_0 and do not reject H_o for Previous Birth (0.386) and Hemoglobin Level (0.124) of mothers since their p-values are greater than 0.05.

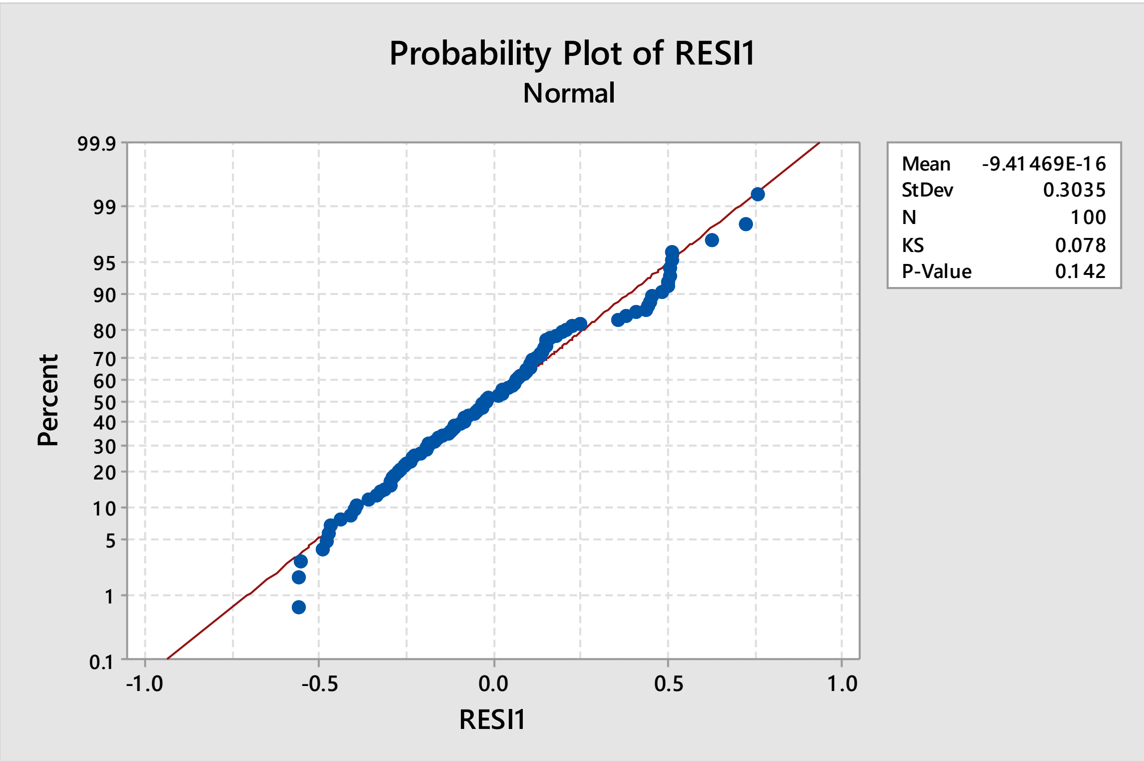

Fig 1: Test of Normality

Using the MINITAB Software via Kolmogorov-Smirnov method, the output is displayed above. The p-value of 0.142 means that the error term for normality assumption is satisfied.

Multi-Collinearity Test

Table d: SPSS Printout

Collinearity Diagnostics[a]							
Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Age	Previous Birth	Hemoglobin Level
1	1	3.579	1.000	.00	.00	.02	.01
	2	.358	3.163	.00	.00	.97	.02
	3	.053	8.179	.03	.12	.00	.85
	4	.010	18.615	.97	.88	.00	.13
a. Dependent Variable: Weight							

Using Equation (21), we have

K $= \frac{0.358}{0.010} = 35.8$, and using Equation (22), we get ;

$$\therefore \quad CI = \sqrt{35.8} \approx 5.98$$

Since CI < 10, the study concludes that there's no critical multicollinearity.

Autocorrelation Test

$H_0 : \rho = 0$ (no autocorrelation)
$H_1 : \rho \neq 0$ (presence of autocorrelation)

Table e: SPSS Printout

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.725[a]	.526	.511	.30820	.526	35.528	3	96	.000	1.339
a. Predictors: (Constant), Hemoglobin Level, Age, Previous Birth										
b. Dependent Variable: Weight										

From Table e, the SPSS printout, Durbin Watson Statistic (D) = 1.339
From the DW table, $D_L = 1.634$, $D_U = 1.698$. Then, 4 –1.634 = 2.366, and 4 – 1.698 = 2.302. Since D = 1.339 < 4- D_u = 2.302, we do not reject H_0, and conclude that autocorrelation does not exist in the data.

Heteroscedasticity Test
$R^2 = 0.614$

Using Equation (24),

$$\therefore \quad \chi^2_{cal} = 100(0.526) = 52.6$$

$$\chi^2_{tab} = \chi^2_{3,0.05} = 7.815$$

Since $\chi^2_{cal} = 52.6 > \chi^2_{tab} = 7.815$, we reject H_0 and conclude that there is presence of heteroscedasticity in the data.

Conclusion and Recommendation
The analysis showed that there is no multicollinearity, autocorrelation which agrees with the assumptions of multiple linear regression. The analysis shows that heteroscedasticity exists in the data. The error term followed a normal distribution using Kolmogorov-Smirnov. The analysis revealed that there is significant association between birth weight and previous number of births, age of mothers & the hemoglobin level of mothers. Further analysis based on the individual test shows that age of mothers contributes positively to birth weight, while previous number of births and hemoglobin level of mothers do not contribute to birth weight. The R^2 is 52.6% which entails that 52.6% variation in the value of birth weight is explained by a change in independent variables. The study concluded that age of mothers is a predictor of weight of babies.
Having concluded the analysis of this work and from the results, the study recommended the following;

1. Similar work be carried out using other mothers' characteristics such as weight, state of health and hereditary factors
2. Other statistical techniques, other than multiple linear regression should be employed to compare result, especially when heteroscedasticity exists in the data, as applies in this study.

3. Mothers should check their H.B levels to ensure adequacy, but however should be bothered about its consequences on their birth weight.

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