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A Study of Demography and Identification of Maternal Factors Affecting Birth Weight

Joel Friday Eniayebinu[1], Bature Funmilayo Kudirat[2], Dahida Terkuma[3], Micheal Vincent Abiodun[4], Lawrence Nzan Edim[5]

[1] Department of Statistics, University of Ilorin, Ilorin.
[2] Government Technical College, Ilorin.
[3] Department of Mathematics, Nigerian Army University, Biu.
[4] Department of Statistics, Federal Polytechnic, Bida
[5]Department of Statistics, Ahmadu Bello University, Zaria.
Email: tajudeenatanda56@yahoo.com

ABSTRACT

This research examines that important indicator of the health status of the infant is the birth weight which are determined by the maternal factors that could affect it, however a model in determining the birth weight is obtained within a duration of gestational age. The purpose of this research work is to advocate the importance of the maternal factors on the birth weight. And it was accomplished using multiple regression on the NCSS and statistical package for social science (SPSS SOFTWARE). The data was collected from the Kaduna state university teaching hospital (Barau Dikko) by selecting 100 sample size of the mother age, mother weight, gestational age, parity, gravida and the birth weight. Using this data, a multiple regression model approach was formulated and test for the significance of the entire model as well as the test on each individual regression coefficient. Also the model was used for testing if correlation exist among the variable under study. The regression as specified in the work provide not to be good predictor of the birth weight. Also, from the model summary, the R and R^2 show that there exist a weak linear relationship between the variable under study indicating how well the independent variables explained the variations in the dependent variable and how well or good the model fit the data. Finally, from the five repressor variables it is shown that gestational age is the only variable that contribute significantly to the model based on the output obtained as the p-value which tend to be less than 0.05(significant level, while other four variables are statistically to the model.

KEY WORDS: Demography, Mother Age, Mother Weight, Gestational Age, Parity, Gravida and Birth Weight

1. INTRODUCTION

King (2019) defined the birth weight of an infant as the most important determinant of its chances of survival, healthy growth, and development and is dependent on many maternal factors such as Gestational Diabetes Mellitus (GDM), mother's age, and mothers' weight.

Furthermore, defines baby's weight as the measures of heaviness of a baby when born, and most baby at birth usually weight 3.5kg (7.5 pound). A healthy mother delivers a healthy baby, and a malnourished mother contributes to low birth weight (LBW) baby. In Nigeria, 97% of new born baby's weights between 2.5kg (5.5 pounds) and 4.5kg (10 gestational age) and babies weighing more than 4.5kg which is considered large for gestational age. Low birth weight (LBW) has been defined as a birth weight of less than 2.5kg regardless of gestational age. World Health Organization (WHO) estimates that globally, out of 139 million live births, nearly more than 20 million LBW babies are born each year, consisting 15.5% of all live births, nearly 95.6% of them in developing countries. Infants who weigh less than 2.5 kg at birth represent about 26% of all live births in Nigeria and more than half of these are born at term. LBW infants are 40 times more likely to die within first four weeks of life than normal birth weight infants. Half of all prenatal and 1/3rd of all infant deaths occur in babies with LBW. Majority of studies done in India on determinate of birth weight are hospital based. Data from hospitals is generally associated with a certain degree of uncertainty and bias. Those who are rural based studies most of them are done in an antenatal clinic situated at rural health training centers or records based. Hence, this study was undertaking in urban health sectors to know the risk factors for birth weight of a new born. Each study has assessed only few or group of risk maternal factors that might influence the duration of gestation or intrauterine growth. The present study has taken into consideration all the risk factor and high lightened important independent factors of birth weight through multiple regression analysis.

According to Bahtiyar (2017) the normal birth weight for babies born at term (between 37 and 40 weeks' gestation) ranges from 2.5kg (5 pounds, 8 ounces) to 4.0kg (8 pounds, 13 ounces) with such a wide range of what is considered normal, it is difficult to predict the birth weight of babies. There are several factors that contribute to this difficulty which include maternal age, pre-existing medical problem, heredity/genetics, mothers' age, mothers' weight, fetal number, gestational age at birth and gestational diabetes mellitus (GDM).

2.1 LITERATURE REVIEW

This research will give a review of related literatures from previous researchers, such as journals/ Magazines, and as on.

According to Wilcox (2019) birth weight is one of the most important variables in the epidemiology. The association between birth weight and prenatal mortality has been confirmed repeatedly, (2017) and to a lesser degree, with developmental problems on childhood (Kumar et al. 2018, Richard et al 2019) and the risk of various diseases in adulthood (Veldi et al 2017) Anderson and Osier 2017, Heidiger et al (2019) in the last two decades, some of relative birth weight risk factors have been investigating e.g. smoking during pregnancy, multiple births, baby's gender, pregnancy problem, parity, mother's job, mother's age, maternal height and weight, gestational age, low income and crowding. It is reported repeatedly that smoking in pregnancy is a major determinant of low birth weight (Spencer 2018 Mess et al 2018, Silva et al 2020, Hosain et al 2006, Johansson et al 2017) and range of adverse pregnancy outcome (Andres and daynes 2018, Spencer 2016, Teramoto et al 2017).

Furthermore, the median birth weighted of first-born is heavier than that of the second-born and it is smaller in triplets Kato(2016) neighborhood socio-economic characteristics may associates with birth weight Parl et al .(2018) and crowding (number of persons per room) was strongly positively related to poor pregnancy outcome Grove and Hughes (2020). The most fundamental measurement of the progress in a pregnancy is gestational age at birth weight (Duncan 2017, canal and Tanaka 2018. Hosain et al. 2017) and teenager mothers have highest rate of low birth weight (LBW), Duncan 2017.

According to Kuhl (2016) maternal smoking, stress, and poor socio-economic condition during pregnancy have been linked with low birth weight babies. Is there any way of deciding which of these related potentials causes is the most important, in an attempt to do that are search group, studied over 15000 pregnant women delivering at a district general hospital in linear London, they showed that the most important influence on fetal growth was smoking, which was associated with a 5% reduction in birth weight after adjustment for maternal height and parity gestation and baby's sex of over 40 socio-economic and psychological factors examined only four were significantly related to a reduction in birth weight and became non-significant after adjustment for smoking. The authors concluded that any effects of stress and poor environment on fetal growth are small compared with the effect of smoking. Maternal characteristics are important group of variable in baby's weight. It has showed that the birth weight was lower in the case of low maternal pre-pregnancy weight and low parity (Teramoto et al. 2017, Johansson et al 2017). It is found that maternal height, pre-pregnancy weight and hospitalization before the 37th week of gestation were significantly associated with BW, (Cavali and Tanaka 2018). There are significant associated with LBW were found (in decreasing order of magnitude) for low maternal weight, short maternal height (Mels et al 2020). It is well known that maternal occupation influence negatively the health of both the baby and mother during pregnancy Macfarlane and Medford 2020, Zadkarami(2019) occupational activity of mother were significantly associated (positively) with LBW Cavali and Tanaka (2018) Giessemann and Hermstom(2019). It is also reported that the birth weight was lower in the case of a low income Teramoto(2017) and increase in the risk of low birth weight.

2.2 Defining Excess Weight

In reviewing weight issues and potential interventions, it is important to first define excess weight. In adults, there is general consensus that excess weight is measured using standard categories of Body Mass Index (BMI). BMI is a direct calculation using height and weight, and is a practical indicator for adults of body fat. In the U.S., adults whose BMI measures 2.5-2.9 kg/m2 are categorized as overweight, 3.0-3.4 kg/m2 as mildly obese, 3.5-3.9 kg/m2 as moderately obese, and > 4.0 kg/m2 as extremely obese (NASMHPD, 2019). The measurement of excess weight in children and adolescents is complex and there has not been experience significance significant variability in BMI as they move through developmental stages. Measurement of BMI may actually underestimate the prevalence of obesity in young people Bloomgarden(2017). Several leading institutes in child and adolescent health, including the American Academy of Pediatrics, the National Heart, Lung, and Blood Institute, and Center for Disease Control and Prevention (CDC), have adopted the standard of measuring overweight and obesity in children and adolescents based upon BMI percentiles. Sex-specific growth charts published by CDC provide norm-referenced age growth data for children and adolescents age 2-19 years, Utilizing these charts, "overweight" is defined as having a BMI above the 85thpercentile and "obese" as having a BMI above 95th percentile of the weight for length.

2.2.1 Causes and Correlates of Excess Weight

Weight control issues arise when there is an energy imbalance. An energy imbalance develops when an individual takes in more calories than they utilize through physical activity. Most Americans do not get enough physical exercise, eat out frequently, and eat large meals

(National Institute of Health [NIH], 2020). Several factors play a role in obesity and overweight, including biological, social, environmental, and medical illnesses (Stein &Colditz 2004). For persons with behavioral health issues, psychiatric symptoms and pharmacotherapy also contribute to weight management challenges.

3.1 RESEARCH METHODOLOGY AND TOOLS/ DATA PRESENTATION

In this research methodology is one of the most crucial chapters that introduce readers to the various methods of data collection as well as discussion as well as discussion of the statistical procedures of collecting and analyzing data, which will be done in this research work. This chapter is aimed at discussing briefly method of data collection and statistical tools used to achieve the stated objective of this project. It gives the theoretical step that can give a successive analysis.

3.2 Method of Data Collection

This is the process of obtaining statistical data, which are being used for analysis in order to draw valid and reasonable conclusion and also in decision making. Basically, there are two main categories of data these are:

Primary data and

Secondary data.

The data used for this research is secondary data. For this research, the data was obtained from Kaduna State University Teaching Hospital (Barau Dikko). These are data have already been compiled and made available by any authorized agent or body for statistical analysis. The data are not originated by the investigator for inquiry at hand but have been used for particular purposes by someone else. It has advantage of saving time and cost when collecting. These data were obtained through experiment to determine the maternal factors affecting birth weight.

3.4 Method of Data Analysis

The statistical tools that is used for the data analysis is regression analysis with the use of matrix approach, due to the nature and pattern of the dataset or observation drawn for the analysis, and also the main objective of the research were also considered.

3.4.1 Regression Analysis

Regression is a tool developed for parameter estimation and model verification. It is a very useful class of model encountered in science and engineering. A commonly occurring situation is one in which random quantity, Y, is a function of one or more independent (and deterministic) variables X1 , X2 , . . . , Xn. Given a sample of Y value with their associated values of X1, for i= 1, 2, . . . , n, we are interested in estimating on the basis of this sample the relation between Y and the independent variables X1 , X2 , ... , Xn.

In general, the model for simple linear regression can be written as:

$Yi = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots\ldots + \beta_k x_k + \varepsilon_i$ ……………………………..**(3.1)**

Where;

β_0= Intercept, β_1 = Slope or coefficient of regression, X_i = Independent variable, Y = dependent Variable, $\mathcal{E}_i$= Error term/white noise.

As one approach to point estimation of regression parameters $\hat{\beta}_o and \hat{\beta}_1$, the method of least squares suggests that their estimates can be chosen so that the sum of the squared differences between observed samples values y_i and the estimated expected value of Y, is minimized. This can be written as;

$\mathcal{E}_i$= yi– ($\hat{\beta}_0 + \hat{\beta}_1 x_i$); for i = 1, 2, -------- n………………………….... (3.2)

The least-square estimates of regression parameters $\hat{\beta}_0$ and $\hat{\beta}_1$, respectively. Are found by minimizing

$$Q = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} (yi(\hat{\beta}_o + \hat{\beta}_{1xi}))^2 \quad \ldots\ldots\ldots\ldots (3.3)$$

In the above, the sample-value pair are (x_1,y_1), (x_2,y_2)…(x_n,y_n), and $\mathcal{E}_i$, i = 1,2, …., n, are called the *residuals*. The estimates are easily found based on the least-square procedure.

$$\hat{\beta}_o = \bar{y} - \hat{\beta}_{1\bar{x}} \quad \ldots\ldots\ldots (3.4)$$

$$\hat{\beta}_1 = \frac{n\sum_{i=1}^{n} xy - (\sum_{i=1}^{n} x)(\sum_{i=1}^{n} y)}{n\sum_{i=1}^{n} (x^2) - (\sum_{i=1}^{n} x)^2} \quad \ldots\ldots\ldots (3.5)$$

Where; $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} xi, \bar{y} = \sum_{i=1}^{n} yi,$

3.4.2 Multiple Linear Regression

Multiple linear regression is one in which the random quantity, Y, is a function of more than one independent (and deterministic) variable X_1 , X_2 ,…, Xn. For the case of this research multiple regressions is used, because the research involves more than one independent variable that is, in particular four independent variables (mother weight, mother age, gestational age, parity) which are to be used to predict the dependent variable (birth weight).

In multiple linear regressions, the model takes the form

Where

β_0= intercept, β_1 = slope of Y with variable Xi, holding variables X_I …., X_n. Constant.

Then for β_1 and Xi is such that for all i = 1, 2, ….,n

$\mathcal{E}_i$= random error in Y for observation i.

Subscript i denotes the observational unit

Method of Estimation of Parameters

There are some methods that can be deployed when working with multiple regressions. These methods are:

- The least square method
- The matrix approach method

3.4.3 Least Square Method of Estimation

The method is used to estimate the regression coefficient in the multiple regression models. Again, we assume that the variance of Y is $\sigma^2$and is independent of $X_1, X_2, ...,X_n$. As in simple linear regression, we are interested in estimating (n + 1) regression coefficients 0,1,.., and m, obtaining certain interval estimates, and testing hypotheses about these parameters on the basis of a sample of Y values with their associated values of $(X_1, X_2, ...,X_n)$. Let us note that our sample size n in this case takes the form of arrays$(x_{11}, x_{21}, ...,x_{n1}, Y_1)$, $(x_{12},x_{22}, ...,x_{n2}, Y_2)$, $(x_{1n}, x_{2n}, x_{3n}....,Y_n)$. For each set of values, n = 1, 2, … , of X_i, Y_i is an independent observation from population Y. The observation is based on the available data;

We wish to estimate the parameters $\beta_0, \beta_1 ..... \beta_n$

$$Y_i = \beta_o + \beta_1 x_{i1} + \beta_2 x_{i2} + ...+ \beta_k x_{ik} + \varepsilon_i \quad ....(3.6)$$

$$Y_i = \beta_o + \sum_{j=1}^{n} \beta_j x_{ij} + \varepsilon_{i,} i = 1, 2...n \quad ....(3.7)$$

The least square function is then,

$$L = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} (y_i - \beta_o - \sum_{j=1}^{k} \beta_j x_{ij})^2 \quad ....3.8$$

We then minimize L with respect to $\beta_0, \beta_1, \ldots, \beta_k$. The least square estimates $\beta_0, \beta_1, \ldots, \beta_k$ must satisfy

$$\frac{\partial L}{\partial \beta_o} (\hat{\beta}_{1,} \hat{\beta}_{2...} \hat{\beta}_k) = -2 \sum_{i=1}^{n} (y_i - \hat{\beta}_o - \sum_{j=1}^{k} \hat{\beta}_j x_{ij}) x_{ij} = 0 \quad j = 1, 2......k$$

As before, we could take derivatives with respect to the model parameters $\beta_0, \beta_1, \ldots, \beta_k$ set them equal to zero and derive the least-squares normal equations that our parameter estimates $\hat{\beta}_{o,} \hat{\beta}_1 ... \hat{\beta}_k$ would have to be fulfill by Simplifying the equation, we then obtain the normal equation as;

$$\sum_{i=1}^{n} y_i = n\hat{\beta}_o + \hat{\beta}_1 \sum_{i=1}^{n} x_{i1} + \hat{\beta}_2 \sum_{i=1}^{n} x_{i2} + \hat{\beta}_3 \sum_{i=1}^{n} x_{i3}$$

$$\sum_{i=1}^{n} x_{i1} y_i = \hat{\beta}_o \sum_{i=1}^{n} x_{il} + \hat{\beta}_1 \sum_{i=1}^{n} x_{i1}{}^2 + \hat{\beta}_2 \sum_{i=1}^{n} x_{i1} x_{i2} + \hat{\beta}_3 \sum_{i=1}^{n} x_{i1} x_{i3}$$

$$\sum_{i=1}^{n} x_{i2} y_i = \hat{\beta}_o \sum_{i=1}^{n} x_{i2} + \hat{\beta}_1 \sum_{i=1}^{n} x_{i2} xi1 + \hat{\beta}_2 \sum_{i=1}^{n} x_{i2}{}^2 + \hat{\beta}_3 \sum_{i=1}^{n} x_{i2} x_{i3}$$

$$\sum_{i=1}^{n} x_{i3} y_i = \hat{\beta}_0 \sum_{i=1}^{n} x_{i3} + \hat{\beta}_1 \sum_{i=1}^{n} x_{i3} xi1 + \hat{\beta}_2 \sum_{i=1}^{n} xi2 x_{i3} + \hat{\beta}_3 \sum_{i=1}^{n} x_{i3}{}^2$$

The multiple regression equation represents a plane (in cases of two predictor variable) or a hyper-plane (in cases of more than two predictors). In multiple regression the coefficient $\beta_{o,}$ is called the constant coefficient. The regression coefficient β_j, for j= 1, 2….k has several interpretations. It may be interpreted as the change in Y corresponding to a unit change in X_j when all other predictor variable are held constant. Magnitude of the change is not dependent on the value at which the other predictor variable are fixed. However, the predictor variables may be inherently related and holding some of the parameter's constants while varying the others may not be possible. The regression coefficient, βj is also called the partial regression coefficient because β_j represents the contribution of X_j to the response variable Y after it has been adjusted for the other predicted variable.

Table1 Analysis of variance for testing significance of regression in multiple linear regressions.

Source of Variation	Sum of Squares	Degree of freedom	Mean Square	F-ratio
Regression	$SSR = \hat{\beta}'XY - \frac{(\sum_{i=1}^{n} Yi)^2}{n}$		$MSR = \frac{MSR}{K}$	$F = \frac{MSR}{MSE}$
Error	$SSE = Y'Y - \hat{\beta}'X'Y$	n-k-1	$MSR = \frac{SSE}{n-k-1}$	
Total	$SST = Y'Y - \frac{(\sum_{i=1}^{n} Yi)^2}{n}$	n-1		

4.1 DATA ANALYSIS AND INTERPRETATION OF RESULTS

This research covers the analysis of data provided in table. The estimation of the regression parameters, descriptive statistics, the correlation of the fitted model, Analysis of variance table and the regression coefficients. All the analysis used in this research work were done using the statistical package known as NCSS and SPSS, and results were presented in meaningful and concise manner for a lay person and reader to understand.

4.2 SPECIFICATION OF MODEL

In this study the birth weight, mother age, mother weight and gravida are the variables to be considered.

Where: Y=Birth weight (BAWE), X_1= Mother Weight (MWE), X_2= Mother Age (MAGE), X_3= Gravida.

4.3 DESCRIPTIVE STATISTICS

This phase is the summary of the statistics of data presented in chapter 3, the statistics include means and standard deviation of the data as can be seen in table 4.4.1 below

Table 4.3.1 Descriptive statistics of the data

Variables	Count	Mean	Standard deviation
Birth weight	100	2.8510	0.62515
Mother age	100	27.2900	6.94756
Mother weight	100	67.9100	13.49156
Gravida	100	2.6700	1.63333

Table 4.3.1 shows that the average birth weight of 100 observations is 2.8510 with a standard deviation of 0.62515, also average of mother age 27.2900 with a standard deviation 6.94756, and mother weight with 67.9100 and standard deviation 13.49156.

4.4 Estimation of regression parameters

Here is the regression parameter, the parameters coefficient using the statistical tools in other to obtain the computation of the model which will be shown in the table below.

Table 4.4.1: THE REGRESSION COEFFICIENT TABLE

Model	**β**	**Std Error**	**Standardized coefficient**	**T**	**Sig**
(constant)	1.743	0.367		4.743	0.0001
Mother age	0.003	0.010	0.031	0.288	0.774
Mother weight	0.013	0.005	0.271	2.770	0.007
Gravida	0.068	0.040	0.176	1.679	0.096

H_0:β_1=:β_2=:β_3=0 (the overall variables in the model are not significant)

$H_{1:}$ $\beta j \neq 0$ (the overall variable in the model are significant)

Reject H_0if P- value is $\leq \alpha = 0.05$.

The regression model is given by

$\hat{y}$=1.743+0.003X_1+0.013X_2+0.068X_3

The regression above can be used to estimate or predict the value of the birth weight based on the maternal factors mother age(X_1), mother weight(X_2) and gravid (X_3) are the values provided in the research. The interpretation of regression parameters:

$\hat{\beta}_0$=1.743 is the constant value of birth weight when all X's are zero.

$\hat{\beta}_1$= with increase in mother age of 0.003per year, it is expected to have about 0.003 increase in the birth weight when other factors are held constant.

$\hat{\beta}_2$= with increase in mother weight of 0.013 per year, it is expected to have about 0.013increase in the birth weight when other factors are held constant.

$\hat{\beta}_3$=with increase in gravida age of 0.068 per year, it is expected to have about 0.068 increase in the birth weight when other factors are held constant.

4.5 TESTING RELATIONSHIP BETWEEN VARIABLES IN THE MODEL

We use the correlation analysis to show the relationship that exists between the variables. The variables in the question are birth weight as dependent variable and the respective independent variables are mother age, mother weight, and gravida.

5.1 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1.1 Summary

Based on the research work, chapter one of this work explained the birth weight as the weight of an infant which is the most important determinant of the infant chances of survival, healthy growth, and development and is dependent on many maternal factors such as mothers' age, and mothers' weight, maternal smoking, multiple births, and mother nutrition during pregnancy. Intrauterine growth and development is one of the most vulnerable processes in human lifecycle and its aberrations can result in lasting profound influence in later life. In the context of developing countries, intrauterine growth has been invariably assessed by birth weight. The birth weight of an infant is a reliable index of intrauterine growth and also a sensitive predictor of newborn's chances of survival, growth and long term physical and psychosocial development, also birth weight is strongly associated with the range of health outcomes, this association have understandably led to an emphasis on birth weight as an epidemiologic endpoint in itself, however, this emphasis is misplaced such that birth weight offers information about population analysis that adjust the effect of birth weight on health outcome by ordinary means are unsound. Even so, the association of birth weight is so diverse as a spectrum of health outcomes which is a genuinely fascinating phenomenon. For the chapter two, related literatures were carefully reviewed. This contain comments, statements, opinions and views of various people and group of persons as extracted from books, magazines and journals having direct or indirect bearing on the topic of the study. In chapter three, these dealt with the procedure for data collection. The method of data collection, and the analysis applied in the research work. Chapter four deals with presentation and data analysis. Tabulation was used in presenting and based on the analysis carried out, the following findings were being made;

i. This research study has provided evidence that there exists a significant relationship between the dependent variable Y (birth weight), and the independent variables X_3 (gravida).

ii. A regression model was fitted that could be used to estimate or predict the weight of a baby in response to the maternal factors used in the research, that is $\hat{y}$=1.743+0.003X_1+0.013X_2+0.068X_3

iii. From the Anova table, the results obtained shows that the Fcal which is greater than the Ftab at $\alpha = 0.05$. Therefore, we conclude that the overall model is significant i.e. the independent variables (mother age, mother weight,gravida) are all significant. Also from the Anova table, we can observe the p-value is (0.032) is less than the level of significance ($\alpha = 0.05$), therefore we reject the null hypothesis and conclude that the entire variables is significant to the predictability of the model.

iv. The coefficient of multiple determinations reveals that 10.8% of birth weight is jointly explained by changes or variation in the mother age, mother weight and gravida while the remaining 89.2% is due to other factors which are not considered in this research.

5.1.2 Conclusion

Based on the statistical analysis carried out in the research work, it revealed that the gestational age affects the birth weight. It is shown that increase in the mother age per year, mother weight by 1 kg,gravida by 1, brings about some increase in the predictability of the birth weight. And in a situation where there is decrease in the gestational; age this leads to the situation of having the preterm birth or undergoing the CS (caesarian section), which is a. problem during child birth. It is accounted for by the maternal factors and foetus death at birth.

5.1.3 Recommendation

Further study can be carried out to see whether there are other possible factors that contribute significantly to the birth weight. Therefore, the standard of the antenatal or health care providers should be improved upon so as to check and balance factors that are responsible for birth complication and prolong labor.

Secondly, to check the doctor to determine if it is safe for the expectant mother to gain less or more than the recommended range, also should go for regular check up to know the welfare of her foetus. Pregnancy is a very personal journey, and what is most important is to take care of yourself, eat a healthy diet and make sure you take your personal vitamin to ensure the foetus and the mother had enough nutrients.

Finally, government should encourage establishment of more health institutions with qualified medical personnel such as doctors, nurses, laboratory technician and dentist etc. and so as to improve and promote health services in the societies.

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