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LOGISTIC REGRESSION ANALYSIS ON THE EFFECT OF SOME VARIABLES ON MATERNAL MORTALITY IN NIGERIA

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Abstract

Maternal death has been considered as an important indicator for the health of the population and the economy as well as social development thus requiring the attention and commitment of the government and every citizen. This study titled "logistic regression analysis on the effect of some variables on maternal mortality in Nigeria" was conducted to determine the effect of two social variables, maternal age and maternal location on maternal mortality in Nigeria. The data used for the study were secondary data from the labor ward of Ahmadu Bello University Teaching Hospital Shika, Zaria-Nigeria. Ten years of data were used for the study, this was 2009-2018. Logistic regression was then applied to determine the effect of these presumed maternal mortality determinant factors. Besides the logistic regression analysis, the Chi-square test of independence was used for a preliminary test. The software package used for the analysis was SPSS version 20. The results from this analysis revealed that maternal location is statistically significant in predicting maternal mortality. However, maternal age was determined to be statistically insignificant in predicting maternal mortality. The analysis indicates that rural women are 58% more likely to die of pregnancy-related conditions as compared to the urban ones, it also indicates that a one year increase of age increases one's risk of dying of pregnancy-related conditions by 2%. The implication of these findings is that the advocates of maternal mortality reduction in Nigeria will need to focus more attention on infrastructural developments such as the construction of feeder roads for villages that may give rural Nigerians easy access to good health facilities and not just on making direct improvements to the healthcare system.

Keywords: Logistic regression, Maternal Mortality, Maternal location, Odd ratio, and Nigeria

1. Introduction

The scourge of maternal death has for decades been the major cause of loss of women of reproductive age [1].This endemic has as well become a serious public health concerns especially in developing countries with Nigeria being one of the highest victims, ranking among the highest and the most vulnerable to the menace in Africa and the world at large [2].

Maternal death is defined as the death that occurs during pregnancy, within 42 days after pregnancy termination, irrespective of pregnancy duration or site, from any cause related to or aggravated by the pregnancy but not from accidental or incidental causes [3].Maternal death had attracted the attention of medical world and justified the reasons for the call of three-quarter reduction in the scourge between 1990 and 2015 made by Millennium Development Goal (MDG) 5. This also justified its inclusion in fifth MDG's eight global development objectives in 2000 [4], [5].

Maternal death has been considered as an important indicator for the health of the population and the economic, political as well as social development, thereby vindicating its implication on the well being of Nigeria as a nation [2].

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A study by [6]reported a chance of a woman dying as a result of pregnancy or childbirth during her lifetime at about one in six in the developing countries unlike about one in 30 000 reported in Northern Europe. In the same vein, the World Health Organisation (WHO) as cited in[7] estimated that 500 000 women in developing countries die every year from complications of pregnancy. An estimate of 58,000 per 100 000 maternal deaths in Nigeria annually compared with 239 per 100 000 live births in the whole developing countries and 12 per 100 000 live births in developed countries was as well reported [8].More than 60 percent of the 53 low-income countries with 99 percent global maternal death rate are in Sub-Saharan Africa[9], [10]**.** In another fashion, [11]opined that females of reproductive age in developed countries, contributed only 1 percent to maternal deaths worldwide**.** Overall,reference [11] reported that the lifetime risk of maternal death is more than 200 times greater for women in poor countries compared to women in Western Europe and North America.

These facts indicate that the maternal mortality ratio in Nigeria is one of the highest in Africa and much higher than the global average of 520,000 maternal deaths which begs the question what is the way out?

2. Literature Review

This section basically based itself on findings and conclusions of the related subject matters. It reviewed the association of maternal mortality with location, age, and other social determinants of maternal mortality. Institutional and individuals' findings on the implications of these social factors on the global maternal mortality trend were reviewed.

Reference [12] estimated Nigeria's annual maternal deaths to be 52,000, a figure that contributes 10% to annual estimates of global maternal mortality. Several researches in Nigeria indicate increasing rate of maternal mortality [13], [14], [15], [16]. A 3-year period 2003–2005 study titled **"**Maternal Mortality Trend in southeast Nigeria: Less Than a Decade to the Millennium Developmental Goals" by[17]indicated a high maternal mortality ratio (MMR) of 902.7=100,000 live births. It also showed a consistent increase in MMR within the period of the study. Disheartening news to all northern Nigerians, this figure is very lower than the figures recorded in this part of the country. Reference[18]established that maternal mortality has increased fourfold at UBTH in Nigeria, over a 20 year period considered in the study. Pregnancy-related complications were identified as the leading causes of death among young women aged 15-19 years[19].

Causes of maternal deaths are still perceived to be only medical thereby seeming to neglect the influence of other factors on the problem. In a bid to appreciate these causes differently,[20] categorized the causes of maternal deaths into medical factors, health factors, reproductive factors, unwanted pregnancy, and socioeconomic factors. The study then revealed significant association the incident and maternal death. References [19], [21], [22] examined the background factors that predisposed women to maternal mortality at the Obafemi Awolowo University hospital in Nigeria. The study investigated their socio demographic characteristics, their use of prenatal care, and the incidence of delay in clinical management. The results showed that the maternal deaths involved women who were younger and of poorer socioeconomic status than the women in the control group. A community-based maternal mortality surveillance study in Sichuan, China, assessed the impact of family planning status on maternal mortality and found that the leading causes of death for both planned and unplanned pregnancies were the same: hemorrhage, postpartum infection, pregnancy-induced hypertension, cardiac diseases, and pulmonary diseases [23].

Case-control study analyzed the risk factors for maternal mortality in three leading hospitals in Dakar, Senegal [24] .The study identified the leading causes of maternal death as puerperal sepsis and other infections, hemorrhage, eclampsia, ruptured uterus, and anemia. The results of the studyalso indicates socio-demographic factors such as location, age, rainy season, being an unmarried and low level of education as correlates of maternal mortality. A seventeen-year review of factors contributing to maternal mortality in North-Central Nigeria identified the greatest risks factors contributing to maternal death as healthcare workers not being skilled enough, financial barriers, failure to use family planning, emergency, antenatal, and delivery care services, young and old age [11], [25], [26].

A study titled "Maternal Mortality in Pernambuco, Brazil: What has changed in ten years?" examined changes in levels and patterns of maternal mortality in Pernambuco, Brazil, in 1994 and 2003 carried out in five sub-regions of Pernambuco using the Reproductive Age Mortality Survey (RAMOS) method identified illegal abortion in Brazil as an important contributory factor for abortion-related deaths [27]. A research on Maternal Mortality and maternity documented two main factors contributing to maternal mortalility: poor health infrastructure and low availability of health personnel among other factors [1].

In a ten-year retrospective study of maternal mortality at the central hospital in Benin City, Nigeria, reference[13] documented the number and pattern of obstetric deaths at the Central Hospital, Benin City, over the ten year period and identified common causes of maternal deaths. The direct leading causes of maternal deaths according to the research were low literacy, high poverty levels, extremes of parity and non-utilization of maternity services.

A population-based qualitative study in two urban and two rural communities in Borno state, Nigeria to find out the community's knowledge and perceived implications of maternal mortality and morbidity as well as the community

members' perception on ways to prevent the scourge. Through focus group discussions the study demonstrated that maternal mortality and morbidity are common and well known in the communities studied and that the implications are well appreciated [28], [29]..

In view of the findings of these kinds of literature, it can be seen that the gap in coverage of some variables such as maternal age and location whose contributions to maternal mortality need to be studied has been identified. The pieces of literature also indicate a time gap because most of them were carried out 5 years back on average.

In a similar thought, [16], [36], [37] also argued that attempts to reduce the high maternal mortality ratio in Nigeria have failed. [16], [36], [37]indicate that this was so because such attempts had been focused on transforming the health system by directly applying expertise and resources on high maternal mortality and its surrounding elements neglecting other avenues that may tremendously help in controlling the problem.

Therefore, the complexities of Nigeria's situation call for a fundamental remedy based on stamping out the problem in the country by the country getting its politics, governance and research structures right. Hence this study intends to solve this issue by using logistic regression analysis to determine the effects of some of these neglected variables on maternal death.

3. Methodology

The study area was Nigeria with the case study of Ahmadu Bello University Teaching Hospital, Shika, Kaduna state, Nigeria. The variables under investigation were maternal age at birth (X_1), maternal location (X_2) and delivery status (Y). The maternal age variable was an interval scale variable. A simple random sample of size 200 women was used. 20 women from each year's maternal record (2009 to 2018) were selected. The information such as delivery status (dead or alive), location (urban or rural area) and the age at birth of each woman was obtained from their clinic records.

The limited findings on the influence of the maternal age and maternal location on maternal mortality reviewed in the literature of this paper show the need to study the following questions and research hypotheses:

a. Is maternal age a significant variable in predicting maternal mortality?
b. Is maternal location a significant variable in predicting maternal mortality?
c. Are rural women at higher risk of maternal mortality compared to the urban ones?

In order to accomplish the set objectives of the study which were formulated in the form of research questions, the following hypotheses were posed and tested:

a. Maternal age is not a significant variable in predicting maternal mortality.
b. Maternal location is not a significant variable in predicting maternal mortality.
c. Rural women are not significantly at higher risk of maternal mortality as compared to the urban ones.

The research design used was a retrospective research design. The data used for the study were secondary data. These data were obtained from the labor ward of Ahmadu Bello University and subsequently analyzed.

The estimation techniques used in this study were logistic regression analysis and Chi-square test of independence.

Justifying the use of this technique in areas of research such as this, references [38], [39] and [40]found logistic regression analysis relevant in similar studies on maternal mobidity and mortality associated with inter pregnancy interval, maternal and perinatal outcomes of twin pregnancy in 23 low-and middle-income countries and moving beyond essential interventions for reduction of maternal mortality: a cross-sectional study respectively.

The logistic regression model is generally presented as

$$g(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p \qquad (3.1)$$

In which case the logit regression model is

$$\pi(x) = \frac{e^{g(x)}}{1+e^{g(x)}} \qquad (3.2)$$

The independent variables in equations 3.1 are assumed to be interval scale variables. If a nominal scale variable with k possible values is being investigated, $k-1$ design variables would be needed.

Suppose that the jth independent variable x_j has k_j levels. The $k_j - 1$ design variables would be denoted as D_{ji} and the coefficients for these design variables would be denoted as $\beta_{ji}, i = 1, 2, \ldots, k_j - 1$. Thus, the logit for a model with p variables and the jth variable being discrete would be:

$$g(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \sum_{i=1}^{k_j-1} \beta_{ji} D_{ji} + \beta_p x_p \qquad (3.3)$$

The construction of the design variables discussed in equation 3.3 is illustrated in Table 3.1

Table 3.1 An illustration of the coding for the design variable with 3 categories

Categories of the variables		
Age groups	D_1	D_2
1	0	0
2	1	0
3	0	1

Logistic regression analysis is generally based on the assumptions that:

a. Each Y_i follows a distribution that is Bernoulli with parameter $E[Y|X] = \pi_{xi}$.
b. The $Y_1, Y_2, \ldots, Y_N$ are independent.
c. The values of the predictors, $X_{i1} = x_{i1} \ldots X_{iN} = x_{iN}$, are treated as fixed.

The chi-square test for independence was used to determine if there is a relationship between maternal location and maternal mortality without quantifying the relationship. This same technique was applied by [41] in order to establish what population characteristics affect the high maternal mortality rate in the sub-Saharan Africa region and to propose possible solutions to reduce this rate. Predictors of maternal mortality in institutional deliveries in Nigeria was another research that applied chi-square test of independence to determine the risk factors for maternal mortality in institutional births in Nigeria. The population characteristics considered by the researchers were mostly social, specifically those more common among rural Africans.

These reported pieces of applications of chi-square analysis indicate the suitability of the technique in this very context. This concept is generally based on the following assumptions:

a. The sampling method is simple random sampling.
b. The variables under study are each categorical.
c. If sample data are displayed in a contingency table, the expected frequency count for each cell of the table is at least 5.

The statistics involved in this test is generally given by

$$X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \sim X^2_{(I-1)(J-I)}\, df \qquad (3.4)$$

where O_{ij} observed frequency count and E_{ij} is the expected frequency counts, which are computed separately for each level of one categorical variable at each level of the other categorical variable. The expected frequencies are computed according to the following formula

$$E_{ij} = \frac{O_{i+} \text{ X } E_{+j}}{N} \qquad (3.5)$$

If the sample findings are unlikely, given the null hypothesis that the variables are independent, the researcher rejects the null hypothesis on comparing the P-value to the significance level and rejecting the null hypothesis when the P-value is less than the chosen significance level.The general format of a contingency table discussed earlier in this section is described in Table 3.2

Table 3.2 General contingency table format

		J				
		1	2	…	j	TOTAL
I	1	O_{11}	O_{12}	…	O_{1J}	O_{1+}
	2	O_{21}	O_{22}	…	O_{2J}	O_{2+}
	⋮	⋮			⋮	⋮
	i	O_{i1}	O_{i2}	…	O_{ij}	O_{i+}
TOTAL		O_{+1}	O_{+2}	…	O_{+J}	N

where I is the number of levels for one categorical variable, and J is the number of levels for the other categorical variable, $Oi+$ is the total number of sample observations at level I, $O+j$ is the total number of sample observations at level j, Oij is the observed frequency count at level $Oi+$ of Variable I, level $O+j$ of Variable J and N is the total sample size.

4. Discussion of Results

As anticipated, these analyses on the contributions of these two perceived causes of maternal deaths in developing countries confirm and oppose many existing literatures and individuals' believe about the clinical role of the factors in questions.

Presented in Tables 4.1, 4.2, 4.3 and 4.4 were the results of the chi-square test of Independence of maternal location on maternal mortality, estimates for logistic regression model's parameters, likelihood ratio test and estimates of some other associated odd ratios.

Table 4.1 Independent test for maternal mortality versus maternal location

Variables	Chi- Square Values	P-Values (*P*)
Maternal Location	7.599	0.006

Table 4.2 Results of Fitting the Logistic Regression Model

Parameter	Estimate	Standard error	Z	P-Values	Exp (OR)
Intercept	-1.002	0.691	2.101	0.147	0.367
Maternal Age	0.020	0.023	0.730	0.393	1.020
Maternal Location	-0.871	0.319	7.457	0.006	0.419

Log likelihood = -116.285

Table 4.3 Likelihood Ratio Test for Model Fit

-2 Log likelihood	Intercept and Covariates	Likelihood Ratio (G)	Critical Value
-2Log likelihood Saturated Model	232.57	41.3	5.99
-2 Log likelihood Fitted Model	273.87		

The results of the Chi-square test of independence($P = 0.006 < 0.05$))conducted indicates that one's location predicts one's risk of maternal mortality, which might be due to ignorance and remoteness of rural women from health facilities who constitute a greater percentage of the maternal mortality cases recorded in the study area of this paper. This agrees with the findings of [30]who indicates that geographic region are statistically significant factors that affect the use of health care services and thereby leading to more maternal mortality among rural women than the urban ones. The frequently cited reports carried out hitherto on cause distribution credited 20% of maternal deaths to indirect causes including effects of maternal age and location globally [38]. This chi-square test result agrees that maternal location does play a role in determing health condition of pregnant women in Nigeria.

These Wald test (Table 4.2) indicates that maternal location is a significant variable in predicting maternal mortality. More specifically, the odd ratio of 0.419indicates that rural women are 0.58 more likely to die of pregnancy conditions as compared to urban ones. This confirms the findings of[31]who cited an odd ratio of 1.15and indicated a significant association between maternal death and rural residence.

The fitted model indicates that an increase in one year of age of a woman increases her risk of dying of pregnancy related conditions by 2%. This is in line with the study of [32]who have demonstrated an increase in perinatal mortality, perinatal death, intrauterine fetal death, and neonatal death in relation to maternal age in childbearing women.

In opposition to the findings of [33], [11] who revealed that adolescents aged 15 years or younger had higher risks for maternal death compared with women aged 20 to 24 years,[34], [35]also reported an increased risk of maternal deaths among women who aged 35 years and above as revealed by this study.

5. Conclusion

Ultimately, the independent test of maternal mortality versus location showed that maternal location was associated with one's risk of dying of pregnancy-related condition. The fitted model also showed that location is a significant determinant of maternal mortality. That is to say that being one from a rural area increases one's risk of maternal death. However, the fitted model did not show a significant relationship between age and maternal mortality, that is, an increase in age does not increase one's risk of maternal death.

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