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# Risk factors and demographic analysis on maternal mortality rate in Nigeria

Iseh, Matthew Joshua[1*], Matthew, Michael Aloysius[2], Michael, Itoro Tim[3]

[1, 2, 3] Department of Statistics, Akwa Ibom State University, Mkpat Enin, Nigeria

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**Abstract**

In many developing countries, maternal mortality is still the leading cause of death for women who are of reproductive age. It is still a major public health concern, particularly in Nigeria. Several risk variables, such as medical, health, reproductive, unintended pregnancy, and socioeconomic factors, have been discovered in studies on maternal mortality using a variety of analytical frameworks. The use of statistical techniques to analyze the maternal mortality rate (MMR) based on demographic characteristics is the main focus of this study. The binary logistic regression model, the chi-square test for independence, the Friedman test statistic and the Mann-Whitney test are some of the statistical tools adopted for in-depth analyses. A total of 3055 pregnant women and 345 recorded cases of deaths after delivery were obtained for the years 2012 to 2023. The result of the binary logistic regression model reveals that there is a high probability that a woman would survive both delivery procedures, however, the probability decreases for women within the age group (10–19). Again, using the Chi-Square statistic at a 5% level of significance, the results indicate that MMR is not independent of age groups but the delivery methods and years of study. In support of the Chi-Square result, the Friedman Statistic shows a significant difference between MMR and age groups, however, no significant difference between MMR and years of study was recorded. Further analysis with the Friedman Pairwise Comparison Test to ascertain the age group that is significant shows that MMR was higher in the age groups (20-29) and (30-39) than in the other age groups. In addition, the Mann-Whitney Statistic analysis shows that there is no significant difference between the methods of delivery. The results obtained from the model and the test statistic show a comprehensive outcome and serve as a guide for policy-making. An insight into the result suggests that early marriage or unsafe abortion could be listed as factors that contribute to MMR within these age groups and as a result, raising the age limit at which young girls can be married for the first time should be encouraged as well as creating awareness to eradicate social stigma, prejudice, and obstacles to safe abortion.



## I. INTRODUCTION

In developing countries, the major challenge in the public health sector is the high rate of maternal mortality, known also as maternal death. For instance, in many sub-Saharan African nations, the mortality rate among women of reproductive age is still a major worry [1]. As explained by [2], "a maternal mortality is the death of a pregnant woman during the cause of delivery or within 42 days of termination of pregnancy, notwithstanding the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes". Health statistics compilation by World Health Organization (WHO) reveals that MMR is estimated at about 1500 daily, of which most of the deaths occur in developing countries. It attributes a total of 99 percent of all maternal deaths to developing countries with mortality ratios of at least 1000 per 100,000 live births in about Fifteen countries of which Nigeria ranks the highest second to India [2, 3]. The findings indicate that maternal deaths represents the biggest difference between industrialized and developing nations. Despite significant global efforts to reduce maternal mortality, Nigeria still have the highest MMR in the world with approximately 15% of global maternal deaths in 2020, translating to 512 deaths per 100,000 live births,

*corresponding author: Iseh, Matthew Joshua
†email: matthewiseh@aksu.edu.ng

which greatly exceeded the Sustainable Development Goal (SDG) target of fewer than 70 fatalities per 100,000 live births by 2030, [4].

[5, 6] collaborated with other authors that Nigeria's maternal mortality ratio has remained high over the past 20 years, accounting for around 20% of all maternal deaths worldwide. However, the country's MMR is declining at a rate of less than 1% per year, while the average global infant and under-five mortality rates have decreased by more than half over the last 40 years [7].Studies have shown a negative correlation exist between a nation's gross domestic product (GDP) and its maternal mortality ratio, which is supported by Nigeria's poor maternal health outcomes. It is however noteworthy that while the GDP of a country is inversely related to its MMR, there are however some discrepancies among developed countries [8, 9, 10, 10].

[11] submitted that Nigeria's health system has been beset by issues with service quality, unwelcoming staff attitudes toward patients, a lack of skills, deteriorating infrastructure, and ongoing shortages of necessary medications. Because of this, WHO placed Nigeria's healthcare system 187th out of 191 UN member nations in 2000. Approximately two-thirds of Nigerian women give birth outside of medical facilities without the presence of medically trained attendants [12]. According to [13], a skilled birth attendant's presence during delivery is crucial for reducing maternal mortality and morbidity. However, a large number of pregnant women in Nigeria are missing the care they require, either due to the fact that there are no services available where they reside or because accessing them is too expensive. In light of this, [14] enumerated the following as the reasons why Skilled Birth Attendance (SBA) is not used during delivery: accessibility issues, opinions about the quality of care, the high cost of services, and other factors like partner support and misreading pregnancy complications. Furthermore, a pregnant woman may not receive the care she requires due to cultural norms or her low social standing [4, 15].

For example, [16] reports that 36.6% of non-targeted areas in Akwa Ibom state are without skilled birth attendance, falling short of the 57% national goal for skilled birth attendance in 2021. Thus, among other things, the low rate of SBA may be related to the high MMR, which is 156 deaths per 1000 live births recorded in the state. Taking cognizant of the facts from the study in Lagos state by [17] that most deaths occur among the age group 25 to 29, accounting for 35.4% of the population considered in the study, it suffices to say that demographic factors such as age, education, income, and geographic location play a significant role in determining maternal health outcomes. However, there is a lack of comprehensive demographic analysis of MMR in Akwa Ibom State. Hence,this study aims to bridge this knowledge gap by conducting a demographic analysis of MMR in Akwa Ibom State, (Eket Local Government Area for the year 2012-2023) by exploring the relationships and trends between demographic factors and maternal mortality rates.

### A. Objectives of the study

The main aim of this study is to carry out a demographic analysis of MMR in Eket Local Government Area of Akwa Ibom State for the year 2012-2023 with the following objectives:

- To determine the relationship between the demographic factors and maternal mortality rates.
- Identify the trends and relationships between the demographic factors and maternal mortality rates.
- Establish if the maternal mortality rates is independent of the age group and years of study.
- verify if there is a significance difference between the age groups and methods of delivery.

### B. Statement of Problem

Despite significant global efforts to reduce maternal mortality, Nigeria's MMR is still among the highest in the world. As reported by WHO, the country accounted for almost 15% of all maternal fatalities worldwide in 2020 with 512 deaths for every 100,000 live births which makes the nation's MMR significantly higher than the SDG objective of fewer than 70 deaths for every 100,000 live births by 2030. Nigeria's high MMR is a complicated problem that is impacted by medical, health, and demographic factors such as age, education, income, location, and cultural background. However, there is a lack of comprehensive analysis to understand the relationships between these factors and maternal mortality in Nigeria. Hence, this work is designed to carry out an in-depth analysis of some of the demographic factors affecting MMR.

### C. Significance of the Study

Other than medical and health factors, this study will provide valuable insights on the effects of some demographic factors to MMR. This will enhance policy decisions, improve maternal health outcomes, reduce health inequalities, and contribute immensely to global sustainable development goals, ultimately helping to reduce maternal mortality and improve healthcare in Eket Local Government as well as Akwa Ibom State. It will avail researchers in this area of interest a bridge of idea to fill the knowledge gap in making policy statement about causes of maternal mortality.

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## II. RELATED LITERATURE REVIEWS

Nigeria's high MMR is a complicated problem that is impacted by several demographic, health, and medical factors, including age, education, income, location, and cultural background. According to Omoruyi [17], five main complications—unsafe abortion, infection, hemorrhage, hypertensive disease of pregnancy, and obstructed labor—account for more than 70% of MMR in Nigeria. The causes of maternal deaths in various parts of Nigeria have been studied by some other researchers using various analytical frameworks. These researchers include [6, 9, 18, 19, 20, 21, 12], who divided the causes of maternal deaths into categories such as medical, health, reproductive, unwanted pregnancy, cultural, and socioeconomic factors. While [21] noticed that the greatest risk of maternal death was noticed among early teenagers and older women, [22] identified a number of characteristics that work against older women's pregnancy outcomes, such as age of first marriage or pregnancy, marital status, educational attainment, maternal body mass index, maternal morbidities prior to the commencement of pregnancy, and pregnancy disorders. Harrison [12] concludes that except the country gets its politics and governance structures right, MMR will still be on the increase.

In support of the result by [12, 22], revealed that in a study to test for MMR in older women in Ibadan, Nigeria, using the socio-demographic characteristics, drugs were administered to 91.9% of the women during labour who were susceptible to some complications. However, using descriptive statistics to analyse MMR with socio-demographic characteristics in Epe local government area of Lagos state, [17] revealed that 35.4% deaths of the entire study population occur among group age (25-29).

Against all the causes identified, [23] summarized the the global causes of maternal deaths to include; direct and indirect causes with 45%, while other health causes take 55% However, according to [24], unsafe abortion, severe postpartum hemorrhage, pre-eclampsia, eclampsia, and delivery difficulties account for 75% of all maternal deaths in Nigeria. In addition, [25, 26] submitted that in Nigeria, 12% of maternal deaths are caused by puerperal sepsis among other factors. Summarizing on the factors so identified, [27] pointed out that, one of the most concerning is a group of women who were compelled to enter the hospital as emergency patients with varying degrees of problems despite never having attended prenatal clinics. In view of this lack of success in determining the actual causes of maternal mortality and the age group that is mostly affected, this study adopts the logistic regression and some non-parametric test statistic approach to further buttress on the key factors responsible for maternal mortality.

## III. METHODOLOGY

This section is considers the methods employed in the collection, description, presentation and analyses of the data.

### A. Source of Data Collection

This study applies data obtained from past records of maternal mortality rates in Eket local government area for the year 2012 to 2023.

### B. Test for Normality Assumption

The normality assumption will be carried out to ascertain the application of either the parametric or non-parametric methods in analyzing the maternal mortality rates. The normality plot or histogram will be used in testing the normality assumption. Given that the data is normally distributed, the parametric methods will be used, otherwise, the non-parametric methods will be applied.

### C. Test for Independence

The test for independence will be employed using the chi-square test in determining if MMR is independent of the age groups and years of study .

### D. Statement of Hypothesis

$H_0$**:** MMR is independent of the age groups.

$H_1$**:** MMR rate is not independent of the age groups.

The chi-square test statistic is;

$$\chi^2 = \sum\sum \frac{(f_o - f_e)^2}{f_e}$$

where $f_o$ and $f_o$ are the observed and expected frequency respectively.

The expected frequency $f_o$ is obtain from the formula

$$f_e = \frac{RT \times CT}{GT}$$

where RT, CT, and GT are the row total, column total and grand total respectively.

The chi-square critical is $\chi^2_{(c-1)(r-1),\,\alpha}$

**Decision/Conclusion:** At α% level of significance, the null hypothesis is rejected if the calculated value is greater than the critical value of chi-square, and conclude that the data is not independent.

### E. Binary Logistic Regression Analysis

The binary logistic regression analysis approach will be employed to obtain the trends between the maternal mortality rates and the demographic factors. Considering a binary response variable y, with y=0,if the woman survives childbirth or y=1,if the woman dies during childbirth. The aim is to

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explain y in terms of the explanatory variables contained in $x_i$. If π is the probability that y=1 then $y \sim B(1, \pi)$. The log odd (logit) is modeled in terms of explanatory variables given as;

$$\ln(\theta) = \ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 = \hat{y}$$

$$\pi = \frac{\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2)}$$

where $\frac{\pi}{1-\pi}$ is the odds ratio which indicates proportionally how much more likely the occurrence of an event is, compared to the non-occurrence. π is the probability of success and yˆ represents the estimated model. $x_1$ and $x_2$ are the independent variables. $x_1$ is the age of the woman and $x_2$ is the delivery method which is coded as;1- Normal delivery and 2- Caesarean section.

### F. Test of Goodness of Fit

The Pearson and Deviance Statistic would be used to determine the goodness of fit test and the model is considered significant if the Pearson and Deviance Statistic is greater than α% level of significance.

### G. Statement of Hypothesis

$H_0$:The model is a good fit

$H_1$:The model is not a good fit

### H. Analysis of Variance

The Analysis of Variance (ANOVA) will be employed to determine if there are significant differences between maternal mortality rates and the age groups/ years of study

### I. Statement of Hypothesis

$H_0$:There is no significant difference between MMR and the age groups

$H_1$:There is significant difference between MMR and the age groups

$H_0$:There is no significant difference between MMR and the years of study

$H_1$:There is significant difference between MMR and the years of study

TABLE 1
ANOVA TABLE

| Sources of Variation | Degree of Freedom | Sum of Squares | Mean Squares | $F$-Ratio | $F$-Critical |
|---|---|---|---|---|---|
| Age groups | a-1 | $SS_a$ | $MS_a$ | $\frac{MS_b}{MS_e}$ | $F_{\infty,b-1,(a-1)(b-1)}$ |
| Years | $b-1$ | $SS_b$ | $MS_b$ | $\frac{MS_b}{MS_e}$ | $F_{\infty,b-1,(a-1)(b-1)}$ |
| Errors | (a - 1)(b - 1) | $SS_e$ | $MS_e$ | | |
| Total | ab-1 | $SS_T$ | | | |

$$SS_a = \frac{1}{b}\sum_{i=1}^{a} y_{i\cdot}^2 - \frac{1}{ab}\left(\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}\right)^2$$

$$SS_b = \frac{1}{a}\sum_{j=1}^{b} y_{\cdot j}^2 - \frac{1}{ab}\left(\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}\right)^2$$

$$SS_T = \sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}^2 - \frac{1}{ab}\left(\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}\right)^2$$

$$SS_e = SS_T - SS_a - SS_b$$

**Decision/Conclusion:** At α% level of significance, if F is less than $\chi^2_{\alpha,\,k-1}$, accept the null hypothesis in each case.

### J. Friedman Test

The Friedman Test is the non-parametric method used in comparing more than two dependent samples. It is an alternate method for a two-way ANOVA when the test for normality is violated. The Friedman Test Statistic is given as;

$$F = \left[\frac{12}{nk(k+1)}\sum_{i=1}^{k} R_i^2\right] - 3n(k+1)$$

where n is the number of blocks, k is the number of treatments and $R_i$ is the sum of the ranks.

### K. Statement of Hypothesis

$H_0$: There is no significant difference between MMR and age groups.

$H_1$:There is significant difference between MMR and age groups.

$H_0$: There is no significant difference between MMR and the years of study.

$H_1$: There is significant difference between MMR and the years of study.

**Decision/Conclusion:** At α% level of significance, if $F$ is less than $\chi^2_{\alpha,\,k-1}$, accept the null hypothesis.

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### L. Mann-Whitney Test

The Mann-Whitney Test is the non-parametric method used in comparing two dependent samples. It is an alternative method for a *t*-Test when the normality assumption is violated. This method will be used in comparing the rate of maternal mortality between the delivery methods for the different age groups. The Mann-Whitney Test Statistic is given as; $U_1 = n_1n_2 + \frac{n_1(n_1+1)}{2} - R_1, U_2 = n_1n_2 + \frac{n_2(n_2+1)}{2} - R_2$ and $U_cal$ is the smallest value between $U_1$ and $U_2$.

**Statement of Hypothesis**

$H_0$: There is no significant difference between maternal mortality rate and the delivery methods.

$H_1$: There is significant difference between maternal mortality rate and the delivery methods

**Decision/Conclusion:** At α% level of significance, if $U_cal$ is less than $U_{(\alpha,\, n_1,\, n_2)}$, reject the null hypothesis and conclude that there is significant difference between maternal mortality rate and the delivery method.

## IV. DATA ANALYSIS AND RESULTS

This section shows the application of the statistical methods in analyzing and visualizing the data obtained from past records of maternal mortality rates in Eket local government area for the year 2012 to 2023 and the interpretation of the results obtained from the analysis.

### A. Normality Test

The normality test assumption was carried out using the Histogram plot

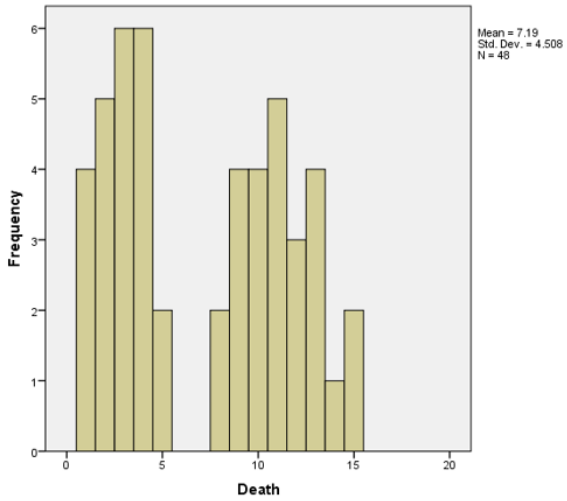


Fig. 1. Histogram Plot for Normality Test

The histogram plot in Fig.1 is not in a bell-shaped form which indicates that the data is not normally distributed. Therefore, the use of non-parametric approach will be employed in comparing the samples.

### B. Binary Logistic Regression

TABLE 2
BINARY LOGISTIC REGRESSION

| | | Chi-square | Df | Sig. |
|---|---|---|---|---|
| Step 1 | Step | 13.624 | 2 | 0.081 |
| | Block | 13.624 | 2 | 0.061 |
| | Model | 13.624 | 2 | 0.084 |

The log odds (logit) is given as;

$$\ln(\theta) = \ln\left(\frac{\pi}{1-\pi}\right) = -0.867 - 0.027x_1 - 0.338x_2 = \hat{y}$$

The probability of the a pregnant woman being dead after delivery is given as;

$$\pi = \frac{e^{-0.867-0.027x_1-0.338x_2}}{1+e^{-0.867-0.027x_1-0.338x_2}}$$

TABLE 3
PROBABILITY OF A PREGNANT WOMAN BEING DEAD OR ALIVE AFTER DELIVERY

| $x_1$ | 14.5 | | 24.5 | | 34.5 | | 44.5 | |
|---|---|---|---|---|---|---|---|---|
| $x_2$ | $\pi$ | 1-$\pi$ | $\pi$ | 1-$\pi$ | $\pi$ | 1-$\pi$ | $\pi$ | 1-$\pi$ |
| 1 | 0.17 | 0.83 | 0.13 | 0.87 | 0.11 | 0.89 | 0.08 | 0.92 |
| 2 | 0.13 | 0.87 | 0.1 | 0.9 | 0.08 | 0.92 | 0.06 | 0.94 |

### C. Statement of Hypothesis

$H_0$: The model is a good fit.

$H_1$: The model is not a good fit.

**Decision/ Conclusion:** The *p*-value (0.084) is greater than 0.05, therefore the null hypothesis is accepted. Hence, the model is a good fit.

### D. Chi-Square Test for Independence

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TABLE 4
SUMMARY OF THE MATERNAL MORTALITY RATE

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | RT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-19 | 4 | 3 | 4 | 3 | 3 | 4 | 4 | 5 | 8 | 4 | 5 | 4 | 51 |
| 20-29 | 9 | 15 | 13 | 15 | 12 | 10 | 12 | 10 | 14 | 9 | 10 | 8 | 137 |
| 30-39 | 12 | 13 | 10 | 11 | 9 | 11 | 13 | 11 | 13 | 11 | 9 | 11 | 134 |
| 40-49 | 2 | 2 | 1 | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 1 | 3 | 23 |
| CT | 27 | 33 | 28 | 32 | 25 | 27 | 30 | 29 | 37 | 26 | 25 | 26 | 345 |

$$f_e = \frac{RT \times CT}{GT}$$

TABLE 5
CHI-SQUARE CALCULATION TABLEAU

| $f_o$ | $f_e$ | $(f_o - f_e)^2$ | $\frac{(f_o-f_e)^2}{f_e}$ |
|---|---|---|---|
| 4 | 3.99 | 0.00008 | 0.000018 |
| 3 | 4.88 | 3.52786 | 0.723180656 |
| 4 | 4.14 | 0.01936 | 0.004676653 |
| 3 | 4.73 | 2.9944 | 0.633008312 |
| 3 | 3.7 | 0.48393 | 0.130946292 |
| 4 | 3.99 | 0.00008 | 0.000018 |
| 4 | 4.43 | 0.18904 | 0.042625746 |
| 5 | 4.29 | 0.50843 | 0.118599524 |
| 8 | 5.47 | 6.4031 | 1.170678095 |
| 4 | 3.84 | 0.0245 | 0.006374188 |
| 5 | 3.7 | 1.70132 | 0.460358056 |
| 4 | 3.84 | 0.0245 | 0.006374188 |
| 9 | 10.7 | 2.96439 | 0.276483656 |
| 15 | 13.1 | 3.5935 | 0.274221748 |
| 13 | 11.1 | 3.53876 | 0.318267066 |
| 15 | 12.7 | 5.25672 | 0.413678859 |
| 12 | 9.93 | 4.29511 | 0.432645721 |
| 10 | 10.7 | 0.52091 | 0.048584224 |
| 12 | 11.9 | 0.00756 | 0.000634719 |
| 10 | 11.5 | 2.29808 | 0.199556426 |
| 14 | 14.7 | 0.47991 | 0.032662876 |
| 9 | 10.3 | 1.75466 | 0.169949304 |
| 10 | 9.93 | 0.00525 | 0.000528933 |
| 8 | 10.3 | 5.40394 | 0.52340242 |
| 12 | 10.5 | 2.2893 | 0.218299805 |
| 13 | 12.8 | 0.03335 | 0.002601616 |
| 10 | 10.9 | 0.76626 | 0.070458268 |
| 11 | 12.4 | 2.042 | 0.164293343 |
| 9 | 9.71 | 0.50431 | 0.051935972 |

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CONT.....

| $f_o$ | $f_e$ | $(f_o - f_e)^2$ | $\frac{(f_o - f_e)^2}{f_e}$ |
|---|---|---|---|
| 11 | 10.5 | 0.26321 | 0.025099142 |
| 13 | 11.7 | 1.81664 | 0.155905256 |
| 11 | 11.3 | 0.06957 | 0.006176762 |
| 13 | 14.4 | 1.87968 | 0.130796663 |
| 11 | 10.1 | 0.81261 | 0.080468061 |
| 9 | 9.71 | 0.50431 | 0.051935972 |
| 11 | 10.1 | 0.81261 | 0.080468061 |
| 2 | 1.8 | 0.04 | 0.022222222 |
| 2 | 2.2 | 0.04 | 0.018181818 |
| 1 | 1.87 | 0.75111 | 0.402380952 |
| 3 | 2.13 | 0.75111 | 0.352083333 |
| 1 | 1.67 | 0.44444 | 0.266666667 |
| 2 | 1.8 | 0.04 | 0.022222222 |
| 1 | 2 | 1 | 0.5 |
| 3 | 1.93 | 1.13778 | 0.588505747 |
| 2 | 2.47 | 0.21778 | 0.088288288 |
| 2 | 1.73 | 0.07111 | 0.041025641 |
| 1 | 1.67 | 0.44444 | 0.266666667 |
| 3 | 1.73 | 1.60444 | 0.925641026 |
| | | | 10.5198 |

$H_0$: Maternal mortality rate is not independent of the age group within the years of study.
$H_1$: Maternal mortality rate is independent of the age group within the years of study.
The chi-square test statistic is;

$$\chi^2 = \sum\sum \frac{(f_o - f_e)^2}{f_e} = 10.5198$$

**Decision/ Conclusion**: At 5% level of significance, the $\chi^2 = 10.5198$ is less than $\chi^2_{0.05,\,(33)} = 47.4$, therefore the null hypothesis is accepted. Hence, maternal mortality rate is not independent of the age group within the year of study.

### E. Independence Test between Age Group and Delivery Methods

TABLE 6
SUMMARY OF THE MATERNAL MORTALITY RATE FOR AGE GROUPS AND DELIVERY METHODS

| | Normal Delivery | Caesarean Section | RT |
|---|---|---|---|
| 10-19 | 36 | 15 | 51 |
| 20-29 | 105 | 32 | 137 |
| 30-39 | 93 | 41 | 134 |
| 40-49 | 18 | 5 | 23 |
| CT | 252 | 93 | 345 |

$$f_e = \frac{RT \times CT}{GT}$$

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TABLE 7
CHI-SQUARE CALCULATION TABLEAU FOR INDEPENDENCE TEST FOR AGE GROUPS AND DELIVERY METHODS

| $f_o$ | $f_e$ | $\frac{(f_o-f_e)^2}{f_e}$ |
|---|---|---|
| 36 | 37.25217 | 0.04209 |
| 15 | 13.74783 | 0.11405 |
| 105 | 100.0696 | 0.242923 |
| 32 | 36.93043 | 0.658243 |
| 93 | 97.87826 | 0.243133 |
| 41 | 36.12174 | 0.658812 |
| 18 | 16.8 | 0.085714 |
| 5 | 6.2 | 0.232258 |
| 345 | 345 | 2.277223 |

$H_0$: The age group is independent of the delivery methods.
$H_1$: The age group is not independent of the delivery methods.
The chi-square test statistic is;

$$\chi^2 = \sum\sum \frac{(f_o - f_e)^2}{f_e} = 2.2772$$

$$\chi^2_{\alpha,\,(r-1)(c-1)} = \chi^2_{0.05,\,(4-1)(2-1)} = \chi^2_{0.05,\,3} = 7.81$$

**Decision/ Conclusion:** At 5% level of significance, the $\chi^2 = 2.2772$ is less than

$$\chi^2_{0.05,\,(3)} = 7.81$$

, therefore the null hypothesis is accepted. Hence, the age group is independent of the delivery methods.

### F. Independence Test between Delivery Methods and the Outcome after Delivery

TABLE 8
SUMMARY OF THE MATERNAL MORTALITY RATE FOR DELIVERY METHODS AND THE OUTCOME AFTER DELIVERY

| | Death | Alive | RT |
|---|---|---|---|
| Normal Delivery | 252 | 1915 | 2167 |
| Caesarean Section | 93 | 795 | 888 |
| CT | 345 | 2710 | 3055 |

$$f_e = \frac{RT \times CT}{GT}$$

TABLE 9
CHI-SQUARE CALCULATION TABLEAU FOR INDEPENDENCE TEST FOR AGE GROUPS AND DELIVERY METHODS

| $f_o$ | $f_e$ | $\frac{(f_o-f_e)^2}{f_e}$ |
|---|---|---|
| 252 | 244.7185 | 0.216658 |
| 1915 | 1922.282 | 0.027582 |
| 93 | 100.2815 | 0.528715 |
| 795 | 787.7185 | 0.067309 |
| 3055 | 3055 | 0.840264 |

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$H_0$: The maternal mortality is independent of the methods of delivery
$H_1$: The maternal mortality is not independent of the methods of delivery
The chi-square test statistic is;

$$\chi^2 = \sum\sum \frac{(f_o - f_e)^2}{f_e} = 0.84$$

$$\chi^2_{\alpha,\,(r-1)(c-1)} = \chi^2_{0.05,\,(2-1)(2-1)} = \chi^2_{0.05,\,(1)} = 3.84$$

**Decision/ Conclusion:** At 5% level of significance, the $\chi^2 = 0.84$ is less than

$$\chi^2_{0.05,\,(3)} = 3.84$$

, therefore the null hypothesis is accepted. Hence, the method of delivery is independent of the outcome after delivery.

### G. Friedman Test

### H. Statement of Hypothesis

$H_0$:There is no significant difference between MMR and the age groups.
$H_1$:There is significant difference between MMR and the age groups.
$H_0$:There is no significant difference between MMR and the years under study.
$H_1$:There is significant difference between MMR and the years under study.

TABLE 10
RANKING FOR COMPARING THE AGE GROUP

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 2 | 1.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 23.5 |
| 3 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 42 |
| 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 42 |
| 1 | 1 | 1 | 1.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12.5 |

$$R_1 = 23.5, \quad R_2 = 42, \quad R_3 = 42, \quad R_4 = 12.5$$

$$n = 12, \quad k = 4$$

$$F_1 = \left[\frac{12}{nk(k+1)}\sum_{i=1}^{k} R_i^2\right] - 3n(k+1) = 31.825$$

$$\chi^2_{\alpha,\,(k-1)} = \chi^2_{0.05,\,(4-1)} = \chi^2_{0.05,\,(3)} = 7.81$$

$$F_{\text{crit}} = F_{\alpha,\,k,\,n} = F_{0.05,\,4,\,12} = 7.9$$

**Decision/ Conclusion:** At 5% level of significance, the

$$F_1 = 31.825$$

is less than

$$\chi^2_{0.05,\,(3)} = 7.81$$

, and

$$F_{\text{crit}} = 7.9$$

, therefore the null hypothesis is accepted. Hence, there is no significant difference between the years of study. The comparison of the maternal mortality rate between the year 2012 to 2023 at 5% level of significance, shows no significant difference.

TABLE 11
RANKING FOR COMPARING THE YEARS OF STUDY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 2 | 6.5 | 2 | 2 | 6.5 | 6.5 | 10.5 | 12 | 6.5 | 10.5 | 6.5 |
| 2.5 | 11.5 | 9 | 11.5 | 7.5 | 5 | 7.5 | 5 | 10 | 2.5 | 5 | 1 |
| 9 | 11 | 3 | 6 | 1.5 | 6 | 11 | 6 | 11 | 6 | 1.5 | 6 |
| 7 | 7 | 2.5 | 11 | 2.5 | 7 | 2.5 | 11 | 7 | 7 | 2.5 | 11 |
| 25 | 31.5 | 21 | 30.5 | 13.5 | 24.5 | 27.5 | 32.5 | 40 | 22 | 19.5 | 24.5 |

$$R_1 = 25, \quad R_2 = 31.5, \quad R_3 = 21, \quad R_4 = 30.5, \quad R_5 = 13.5, \quad R_6 = 24.5, \quad R_7 = 27.5, \quad R_8 = 32.5$$

$$R_9 = 40, \quad R_{10} = 22, \quad R_{11} = 19.5, \quad R_{12} = 24.5$$

$$n = 4, \quad k = 12$$

$$F_2 = \left[\frac{12}{nk(k+1)}\sum_{i=1}^{k} R_i^2\right] - 3n(k+1) = 10.3077$$

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$$\chi^2_{\alpha,\,(k-1)} = \chi^2_{0.05,\,(12-1)} = \chi^2_{0.05,\,(11)} = 19.68$$

**Decision/ Conclusion:** At 5% level of significance, the $F_2 = 10.3077$ is less than $\chi^2_{0.05,\,(11)} = 19.68$, therefore the null hypothesis is accepted. Hence, there is no significant difference between the years of study. The comparison of the maternal mortality rate between the year 2012 to 2023 at 5

### I. Friedman Pairwise Comparison Test

The Friedman Pairwise Comparison Test is used here to test for the significant difference between the age groups of the women.

$H_0$:It is not significant

$H_1$:It is significant

$$S_{ij} = \frac{|R_i - R_j|}{\sqrt{2\left(\frac{bR^* - \sum R^2}{(b-1)(k-1)}\right)}}$$

where;

$$R^* = \sum r(X_{ij})^2 = 359.5$$

$$\sum R^2 = 23.5^2 + 42^2 + 42^2 + 12.5^2 = 4236.5$$

$$R_1 = 23.5, \quad R_2 = 42, \quad R_3 = 42, \quad R_4 = 12.5$$

Comparing age group (10-19) and (20-29):

$$S_{12} = \frac{|R_1 - R_2|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|23.5-42|}{2.1672} = 8.54$$

Comparing age group (10-19) and (30-39):

$$S_{13} = \frac{|R_1 - R_3|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|23.5-42|}{2.1672} = 8.54$$

Comparing age group (10-19) and (40-49):

$$S_{14} = \frac{|R_1 - R_4|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|23.5-12.5|}{2.1672} = 5.08$$

Comparing age group (20-29) and (30-39):

$$S_{23} = \frac{|R_2 - R_3|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|42-42|}{2.1672} = 0$$

Comparing age group (20-29) and (40-49):

$$S_{24} = \frac{|R_2 - R_4|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|42-12.5|}{2.1672} = 13.61$$

Comparing age group (30-39) and (40-49):

$$S_{34} = \frac{|R_3 - R_4|}{\sqrt{2\left(\frac{(12\times359.5)-4236.5}{(12-1)(4-1)}\right)}} = \frac{|42-12.5|}{2.1672} = 13.61$$

$$t_{(n-k),\alpha} = t_{(48-4),0.05} = 2.02$$

TABLE 12
COMPARISON TABLEAU

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 8.54 | 8.54 | 5.08 |
| 2 | 8.54 | 0 | 0 | 13.61 |
| 3 | 8.54 | 0 | 0 | 13.61 |
| 4 | 5.08 | 13.61 | 13.61 | 0 |

$p < 0.05$ compared to Indomethacin group. Data are presented as mean ± standard deviation.

The comparison between age groups [(10-19) and (20-29)], [(10-19) and (30-39)], [(10-19) and (40-49)], [(20-29) and (40-49)], and [(30-39) and (40-49)] were greater than

$$t_{\text{crit}} = 2.02$$

, therefore, they were significant. Hence, the age groups (10-19) and (40-49) caused the rejection of the null hypothesis of equality in the maternal mortality rates among the age groups. From the rank sums of the age groups, the rank sums of the age groups (10-19) and (40-49) were smaller than the rank sums of the age groups (20-29) and (30-39), which shows that the maternal mortality rate was higher in the age groups (20-29) and (30-39) than the other age groups.

### J. Mann-Whitney Test

### K. Statement of Hypothesis

$H_0$:There is no significant difference between MMR and delivery methods.

$H_1$:There is significant difference between MMR and delivery methods.

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TABLE 13
RANKING FOR MANN-WHITNEY TEST

| | 10-19 | 20-29 | 30-39 | 40-49 | Rank Total |
|---|---|---|---|---|---|
| Normal Delivery | 36 (5) | 105 (8) | 93 (7) | 18 (3) | 23 |
| Caesarean Section | 15 (2) | 32 (4) | 41 (6) | 5 (1) | 13 |

$$n_1 = n_2 = 4, \quad U_1 = 4(4) + \frac{4(4+1)}{2} - 23 = 3$$

$$U_2 = 4(4) + \frac{4(4+1)}{2} - 13 = 13$$

$$U_{\text{cal}} = 3, \quad U_{\alpha,n_1,n_2} = U_{0.05,4,4} = 1$$

**Decision/Conclusion**: At 5% level of significance, $U_{\text{cal}} = 3$ is greater than $U_{\alpha,n_1,n_2} = 1$, therefore the null hypothesis is accepted. Hence, there is no significant difference between the method of delivery.

## V. DISCUSSION

A total of 3055 pregnant women and 345 recorded cases of death after delivery were obtained from the year 2012 to 2023. As shown in Table III, the result from the logistic regression model indicates that the probability of a woman being alive after delivery was high for both methods of delivery with 83%, 87%, 89%, and 92% in normal delivery and 87%, 90%, 92%, and 94% in Caesarean Section for age groups (10-19), (20-29), (30-39) and (40-49) respectively, which increases as they get older. A goodness of fit test shows the model was a good fit. Again, the normality test was carried out on the data as shown in Figure I, and the result shows that the data is not normally distributed, therefore, the non-parametric method (Friedman Test Statistic) is substituted for the Analysis of Variance method. Using the Chi-Square statistic at 5% level of significance, the result shows that the maternal mortality rate is not independent of age groups, however, the test is independent of the years of study. The result also shows that, at a 5% level of significance, age groups and MMR are independent of the delivery methods.

At the 5% level of significance, the Friedman Statistic analysis reveals a significant difference between MMR and age groups; however, the test also demonstrates that there is no significant difference between MMR and years of study. The outcome of the Chi-square test of independence is validated by this. The results of the Friedman pairwise comparison test also indicate that there was a significant difference between the MMR and age groups for the age groups (10-19) and (40-49). As a result, the null hypothesis that the maternal mortality rate was equal for all age groups was rejected. According to the age group rank sums, the age groups (10–19) and (40–49) have smaller rank sums than the age groups (20–29) and (30–39). This indicates that the maternal mortality rate is higher in the latter two age groups than in the others. According to the Mann-Whitney Statistic analysis, there is no discernible difference between MMR and the delivery methods at the 5% level of significance.

Consequently, relying on the logistic regression model, MMR is prevalent within the age group (10-19) and gradually reduces as the women get older. This result is in agreement with that of [17] and [18], although the former had included older women as being affected by high MMR. However, the pairwise rank test says otherwise that the maternal mortality rate is higher in the age groups (20-29) and (30-39) than in the other age groups. This result also agrees with the literature by [22], who noticed a high rate of maternal mortality within the age group (25-29). In addition, the Mann-Whitney Statistic has given a pathway that there is no significant difference between MMR and the methods of delivery. Consequently, further studies are required to ascertain the non-parametric test statistic that will conform to the result of the binary regression model.

Moreover, this study has gone ahead of the work done by [11, 22] in using descriptive statistics in the demographic analyses of MMR in that, the data used in this study is subjected to a normality test to ascertain which statistical method will best explain the result. This study stands out among several other research on MMR whose area of interest revolves around medical and health factors. It suffices to say that this study has provided valuable insights on the effects of some demographic factors on maternal mortality rate which aligns with the report by [23] that, other direct and indirect causes of maternal mortality rates contribute 37% of the overall causes.

## VI. CONCLUSION

This study has identified a relationship between maternal mortality rates and some demographic factors with an outstanding goodness of fit to support the model. It has been established that maternal mortality rate is not independent of the age groups but years of study, and further analysis confirms that there is a significant difference between MMR and age groups. However, the test confirms no significant difference between MMR and years of study. In addi-

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tion, there is no significant difference between MMR and the methods of delivery. This serves as a guide to women of diverse cultural beliefs, health professionals and researchers that undergoing a cesarean section or normal delivery has an almost equal chance of outcome. As a matter of fact, there is a slight difference in the higher probability of successful delivery through cesarean section than normal delivery.

The results obtained from the model and that from the test statistic show a comprehensive outcome and serve as a guide for future study. Evidence from the result of this study has given a justification that relying on the model alone will give a misleading conclusion and carrying out the test statistic without subjecting the data to a normality test could also present a false inference. Hence, this study has offered a pathway to enhance policy decisions, improve maternal health outcomes, reduce health inequalities, and contribute to achieving global sustainable development goals, ultimately helping to reduce maternal mortality rate in Eket Local Government as well as Akwa Ibom State. It will avail researchers in this area of interest a bridge of idea to fill the knowledge gap in making policy statement about causes of maternal mortality. It is useful to say that, considering the outcome of the logistic regression model and that of the Friedman pairwise comparison test, the age limit at first marriage for young girls should be increased to reduce MMR within the age group (10-19) and proper sensitization should be made to eradicate the barriers to safe abortion, discrimination and social stigma as this will reduce the risk of MMR within that age groups (20-29) and (30-39). Proper education and full participation in antenatal programs should be enhanced among women at first pregnancy. Proper data collection and monitoring systems should be implemented to identify and follow-up on the outcome of pregnant women and track progress toward reducing maternal mortality rates.

This study is limited to the information provided to the authors who would have considered other socio-demographic factors which would have enhanced a clear cut identification of factors/causes of maternal mortality. Consequently, future researches are needed to bring in more socio-demographic indicators that contribute to MMR and the non-parametric test statistic whose result will align with that of the logistic regression model or any other statistical model.

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