Statistical Analysis on the Factors and Causes Affecting Maternal and Infant Mortality in Nigeria

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DOI: 10.56201/ijasmt.v8.no1.2022.pg27.37

Abstract
Maternal and infant deaths are devastating medical complication in many countries, in which Nigeria is not exempted. It has been realized that complication of child birth and pregnancy are leading causes of death among women of reproductive ages. Therefore, this study aimed at determining the factors responsible for maternal and infant mortality in Nigeria between 2000 and 2019. The descriptive statistics of the skewness shows that the distribution of the data is fairly symmetrical and the time plot displays a downward and gradual decreasing trend for both maternal and infant mortality over the considerable years. The trend analysis of the model produces forecast performance with percentage accuracy measures of MAPE with 3% and 2% for both maternal and infant mortality. The exploratory data analysis (EDA) of maternal and infant mortality under the study shows that the prevalence of undernourishment rate is not significant to the model at 5% level of significant. Therefore, prevalence of undernourishment rate is the major factor affecting the death of the child and mother at the child birth. Hence, the government are hereby implored to improve on training levels of pregnant women at the antenatal stages and empowering families and communities to reduce maternal and infant deaths.

Keywords: *Maternal mortality, infant mortality, time plot, trend analysis, exploratory data analysis*

1. Introduction

Maternal and infant deaths reduction is very important and part of the aims of international developmental goals. Any attempt of health program and policies aiming to reduce maternal and infant deaths needs reliable information. Despite considerable efforts to reduce maternal mortality, numerous pregnant women continue to die in many developing countries, including Nigeria. Nigeria is still ranked second in the world for maternal mortality (Sageer et al., 2019). The aim of this research is to study the maternal and infant factors and effects contributing to maternal and infant mortality in Nigeria. The study examines the effect of infant and maternal mortality in Nigeria using structured and validated data. The data collected was extracted from the existing world bank and United Nations database, which covers a period of 19 years from

(2000 – 2019) using Nigeria as a case study. The objectives are to carry out the explanatory data analysis (EDA) of maternal and infant mortality in order to determine the factors that affect maternal and infant mortality using regression analysis and to determine the causes of infant and maternal mortality in Nigeria.

Mortality is denoted as one of the components of population change. It is measured by relating death in a given period of time to the total population at risk. This type of population could be distinguished by sex, education, occupation, age and information on mortality levels, trends and differentials. Maternal deaths is a global problem that serves as a visible health indicator of a nation's health care system. As part of the 5th Millennium Development Goal, the United Nations set a goal to reduce maternal mortality by three-quarters for all national and regional populations between 1990 and 2015. Maternal mortality is one of the most important indicators of a country's socioeconomic and health status, which is why the UN made maternal mortality reduction one of its goals and set a target of halving maternal mortality by three-quarters between 1990 and 2015 as part of the 5th Millennium Development Goal (MDG5). The United Nations Millennium Development Goals have 8 goals that the UN Member States agreed to try to achieve by the year 2015. The United Nations Millennium Declaration, signed in September 2000, commits world leaders to tackle discrimination against women, hunger, disease, poverty, illiteracy, and environmental degradation. Amongst which are Development goals 4 (reduce child mortality) and 5 (improve maternal health), the MDG didn't really meet their proposed target, so the MGDs were succeeded by the SDGs (sustainable development goals). The United Nations created a set of 17 distinct but interrelated goals to guide global development between 2015 and 2030. Each goal has a set of targets 169 altogether, with subsets of indicators targeted 232 in total. SDGs 3 encompasses both Maternal and Neonatal deaths as good health and well-being.

Najlaa and Humam (2018) reported that the maternal mortality ratio was highest (250) in developing countries and lowest (16) in developed for every 100,000 live births during 2013. Improvement of maternal health has become a source of concern in Nigeria. Alhassan et al. (2021) used bivariate and multivariate logistic regression to assess predictors of timing of neonatal death in which all neonates who died in the Neonatal Intensive Care Unit from 2013 to 2017 were all included and data was obtained from admission, discharge books and mortality records. Their aims describe the causes of neonatal mortality and to evaluate predictors of the timing of neonatal death at the Tamale Teaching Hospital, where they reported that Neonatal deaths now account for more than two-thirds of all deaths in the first year of life and for about half of all deaths in children under five years and found that almost 3/4 of neonatal deaths were within the first week and these deaths were more likely to be associated with preterm birth complications or birth asphyxia. Most of the deaths occurred in babies born within health facilities, presenting an opportunity to reduce mortality by improving on the quality of care provided during the perinatal period. WHO (2019) reported that Sub-Saharan Africa, with a rate of 28 deaths per 1,000 live births, contributes up 41% of the total burden of neonatal deaths worldwide.

Lawn et al. (2005) in a global maternal and neonatal surveillance, reported that a substantial reduction in maternal deaths had been achieved in the past two decades from 543,000 deaths in 1990 to an estimated 287,000 by 2010 with an annual global reduction of 3.1%, however; it still considered a global crisis in the current century. In most developing countries, the major medical causes of maternal mortality are hemorrhage, hypertensive diseases of

pregnancy and various types of maternal infections (Say et.al 2014). Whereas in USA, there is a dramatic reduction in these causes but what emerged were underlying or worsening medical conditions such as cardiovascular diseases. The widest disparity in health statistics compiled by the World Health Organization between developed and developing countries occurred in the area of maternal mortality, with the developing countries contributing most of the figures. At the close of the Millennium Development Goals (MDGs), Despite substantial progress, challenges remain. The majority of low-income countries (LICs), particularly in Sub-Saharan Africa and post conflict settings, have not made sufficient progress to meet MDG 5a. The post-2015 agenda on sustainable development is broader than the MDG agenda, with a greater number of nonhealth goals and a strong focus on inequity reduction; the new agenda includes an absolute reduction in maternal mortality as a marker of progress. Nigeria, like many other Sub-Saharan African countries, had not only failed to meet the targets, but still had high maternal and perinatal morbidity and mortality rates. This new indicator is expected to be framed as targets for preventable maternal deaths (Bustreo et. al 2013; Gilmore and Camhe Gebreyesus 2012).

Thousands of women die each year due to difficulties during pregnancy, childbirth, or the postpartum period around the world, with the majority of deaths occurring in developing nations. These trends had been deemed undesirable in recent decades, as they remained a public health issue requiring the attention of all stakeholders in maternal and child health care. Therefore, focusing on neonatal and maternal mortality in low and middle income in Nigeria. In 2013, United Nations (UN) mortality estimate in Ethiopia for the neonatal death rate was 28 per 1000 live births. Despite the fact that there is an achievement observed in the decrease of neonatal mortality by 48%, still neonatal mortality is high.

Imtiaz Jehan et al. (2009), in their study evaluated the prevalence, sex distribution and causes of neonatal mortality, as well as its risk factors, in an urban Pakistani and found out a high neonatal mortality rate, which is often due to preventable conditions with good access to professional care. In general, it is observed that the rate at which women give birth to babies is high, and also death is recorded almost every day. Every year, about 287,000 women die from pregnancy-related causes. Maternal health and newborn health are closely linked. Nearly three million newborn babies die every year, and an additional 2.6 million babies are stillborn (WHO 2014).

Nigeria is a country that is characterized by many problems ranging from poverty, insecurity, political instability, geographical barriers and decayed social infrastructure including health facilities. Therefore, the country is fighting challenges of health socio-demographic which include life expectancy (low), high maternal and infant mortality, high fertility rate and communicable diseases. Nigeria has the world's second-highest annual maternal mortality rate in 2010, according to the World Health Organization, accounting for 14% of all maternal mortality globally. As of 2015, Nigeria's maternal death rate was around 814 per 100,000 live births. According to statistics from the National Demographic and Health Survey (NDHS), the Maternal Mortality Rate (MMR) differs between geopolitical zone within Nigeria, with southern Nigeria having one of the lowest rates of preventable Maternal and Perinatal mortality.

We follow up this section with the methods and materials. Results and interpretations are delivered in section 3 and conclude in section 4.

2. Methods and Materials

The data used for this study was collected from National population commission, National Bureau of Statistics and World bank indicators for Nigeria which cover a period of 19 years (2000– 2019). In this section, we present our model for describing maternal and infant mortality. Statistics for normally distributed data includes regression of parameters against time or spatial measure. Since the data requirement are satisfied, we employ multiple linear regression analysis to compute the factors that affect maternal mortality and infant mortality rates. The factors considered were the Unemployment rate of women, Educational attainment, Labor force participation rate, Smoking prevalence, and Prevalence of undernourishment. The Multiple Regression Model is represented as:

$$Y_t = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e_t$$

where Y_t is the Maternal mortality/Infant mortality, X_1 = Unemployment rate, X_2 = Educational attainment, X_3 = Labor force participation rate, X_4 = Smoking prevalence, X_5 = Prevalence of undernourishment.

Statistical Trend Analysis Method

We also consider trend analysis to understand how the past maternal and infant mortality data affects the future ones. Trend analysis is a statistical technique performed to evaluate hypothesized linear and nonlinear relationships between two quantitative variables. Classically, it is implemented either as regression analysis or as an analysis of variance for quantitative variables. Trend analysis is usually used in situations when data have been collected over time or at different levels of a variable; especially when a single independent variable, or factor, has been manipulated to observe its effects on a dependent variable or response variable. In particular, the means of a dependent variable are observed across conditions, levels, or points of the manipulated independent variable to statistically determine the trend of such relationship.
However, the model for linear trend analysis is given as:

$$Y_t = b_0 + b_t t + e_t$$

Where Y_t is the dependent variable, b_0 is the constant, b_t is the coefficient, t is the value of the time unit and e_t is the error term.

Mean Absolute Percentage Error (MAPE)

This measures the accuracy of a method for constructing fitted time series in Statistics and this expresses as a percentage and it's defined as follows:

$$\text{MAPE} = \frac{100}{\text{N}} \sum_{\text{i}=1}^{\text{N}} \left| \frac{\text{y}_\text{t} - \hat{y}_t}{y_t} \right|$$

Mean Absolute Deviation (MAD)

This measures the accuracy of fitted time series values and expresses accuracy in the same units as data and is defined as follows:

$$\text{MAD} = \sum_{\text{i}=1}^{\text{N}} \frac{\left|\text{y}_\text{t} - \hat{y}_t\right|}{N}$$

Mean Square Deviation (MSD)

This always computed using the same denominator, n, regardless of the model and is defined as follows:

$$\text{MSD}= \sum_{i=1}^{N} \frac{|y_t - \hat{y}_t|^2}{N}$$

where y_t is the actual values at time t, $\hat{y}_t$ is the estimated values at time t and N is the number of observations.

3. Results and Interpretations

3.1 Descriptive statistics for Infant and Maternal Mortality

Table 1

Variable	Maternal Mortality	Infant Mortality
Mean	1019.9	88.45
SE Mean	22.9	2.43
Std. Dev.	102.5	10.85
Variance	10497.5	117.8
Coef. of Var.	10.05	12.27
Minimum	910	74.2
Q1	934	79.72
Median	982.5	85.35
Q3	1117.5	97.37
Maximum	1200	110
Skewness	0.78	0.64
Kurtosis	-0.9	-0.74

The Table 1 above shows that the descriptive statistics of infant and maternal mortality study in Nigeria between 2000 and 2019.

3.2 Time plot of Infant and Maternal Mortality

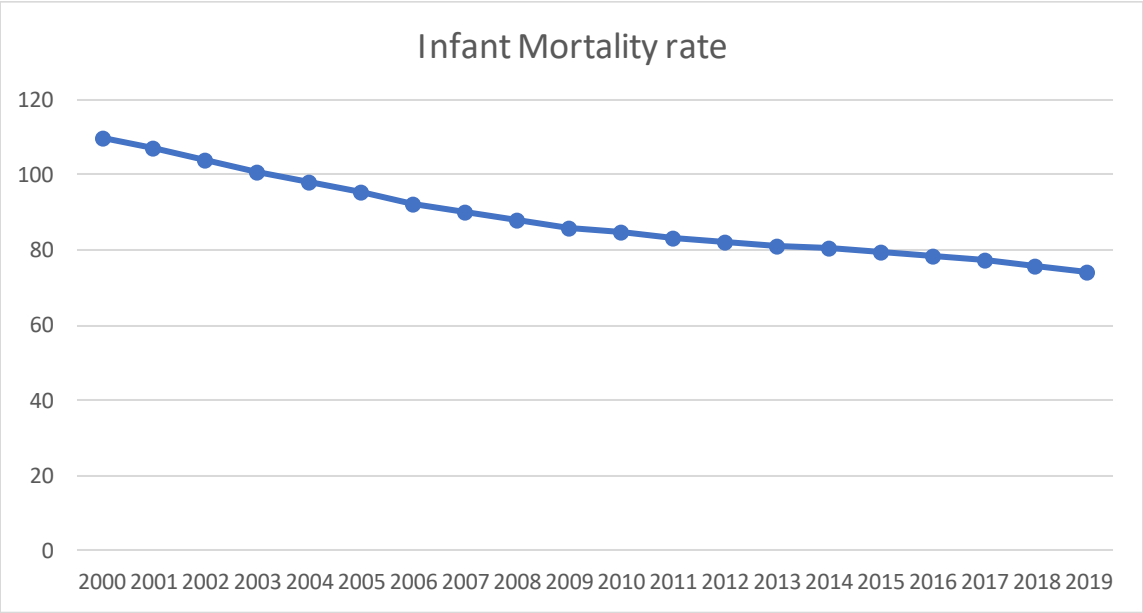

Figure 1: Time plot for infant mortality

Figure 1 above shows the time plot of the infant mortality between 2000 and 2019 exhibiting a downward trend over the considerable years.

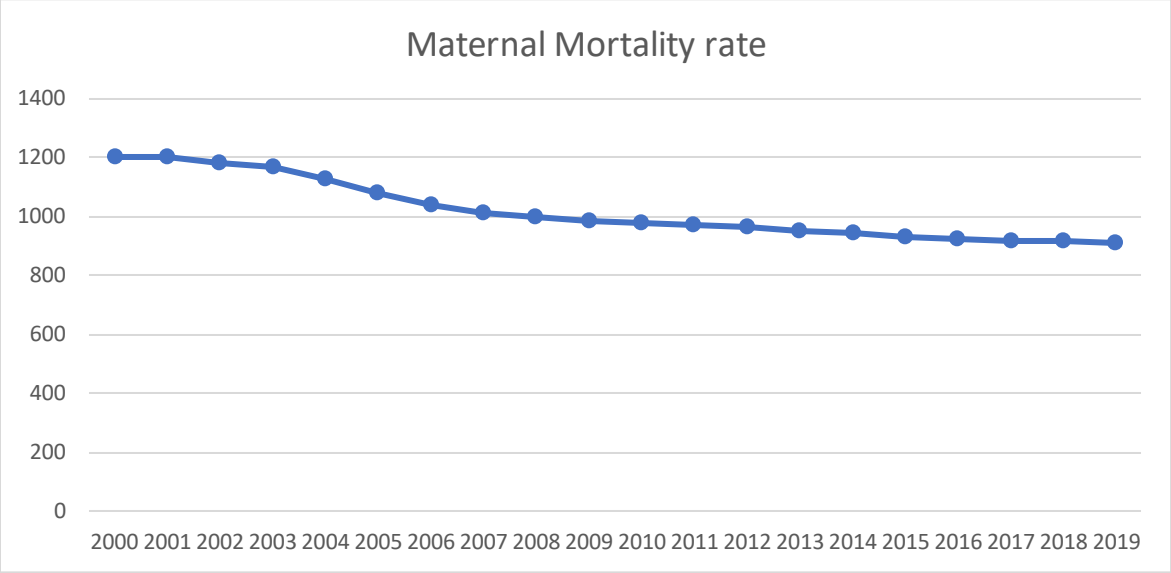

Figure 2: Time plot for maternal mortality rate

Figure 2 displays the time plot of the maternal mortality between 2000 and 2019, showing

a downward trend over the considerable years. This indicates a gradual decrease in maternal mortality over the years.

3.2 Trend Analysis of Infant and Maternal Mortality

The Trend analysis was carried out to obtain the fitted model of the study in order to show the movement of infant and maternal mortality variables over time. This can be used to forecast for the future values of the infant and maternal mortality rate in Nigeria above 2019.

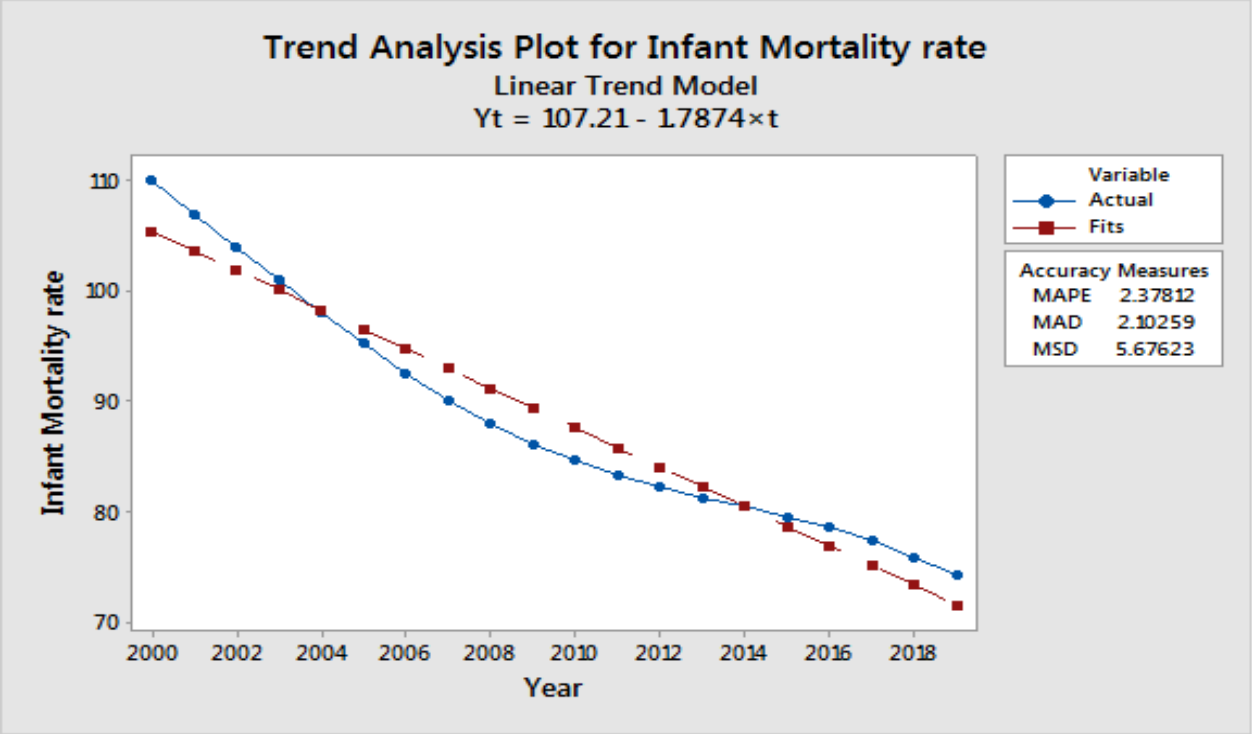

Figure 3: Trend analysis plot for infant mortality rate

Figure 3 shows the plot of linear trend model for infant mortality placed over the time plot in Nigeria. Using the infant mortality data, a trend model consisting of the infant mortality as the dependent variable and year as the independent variable is obtained. The trend model is given as:

$$y_t = 107.21 - 1.7874t$$

Y_t is the Infant mortality and t is the year. The model produces forecast performance with accuracy measures of Mean Absolute Perfect Error (MAPE); expressing accuracy as a percentage of the error. MAPE is 2.37812, on average, meaning the forecast is off by 2%.
Mean Absolute Deviation (MAD); expressing accuracy in the same unit as the data, which helps conceptualize the amount of error. Outliers have less of an effect on MAD which is 2.10258
Mean Square Deviation (MSD); measures the accuracy of the fitted time series values. Outliers have a greater effect on MSD which is 5.67623.

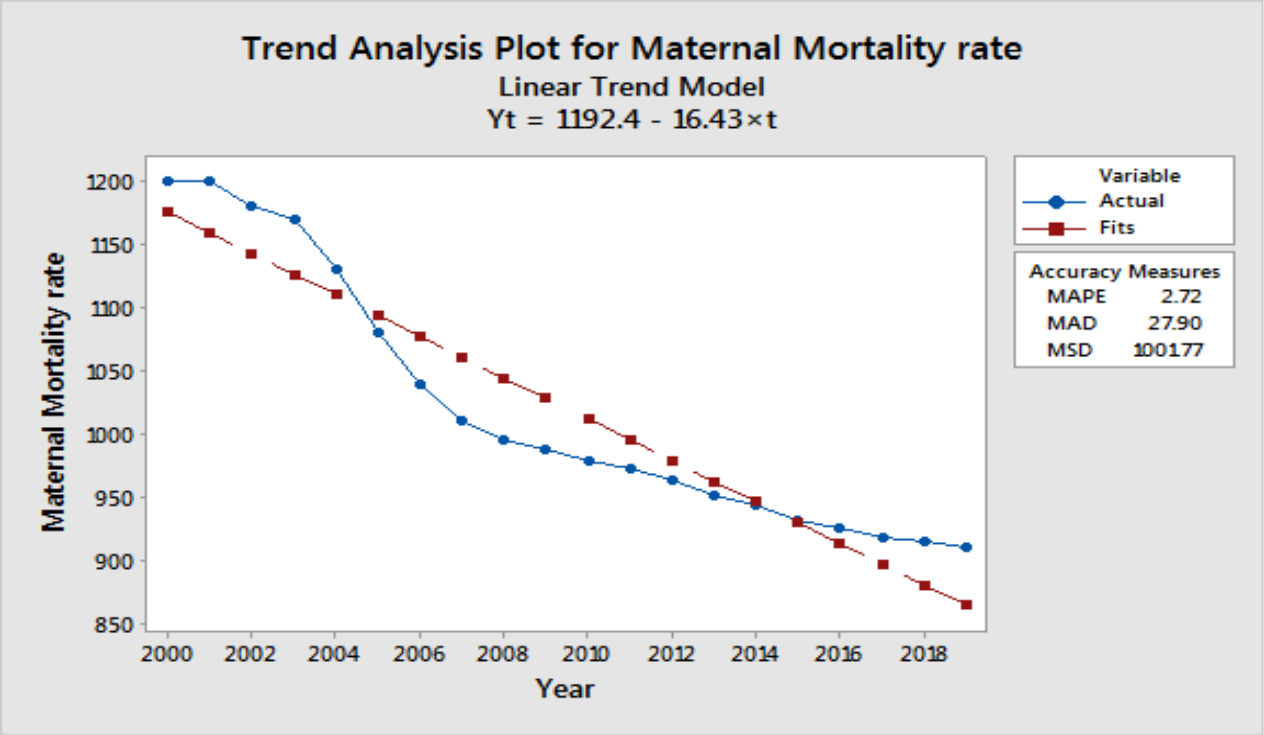

Figure 4: Trend analysis plot for maternal mortality rate

Figure 4 above shows the plot of linear trend model for maternal mortality placed over the time plot in Nigeria. Using the maternal mortality data, a trend model consisting of the maternal mortality as the dependent variable and year as the independent variable is obtained. The trend model is given as

$$Y_t = 1192.4 - 16.43t$$

where Y_t is the maternal mortality rate and t is the year.

The model produces forecast performance with accuracy measures of Mean Absolute Perfect Error (MAPE); expressing accuracy as a percentage of the error. MAPE is 2.72, on average, meaning the forecast is off by 3%. Mean Absolute Deviation (MAD); expressing accuracy in the same unit as the data, which helps conceptualize the amount of error. Outliers have less of an effect on MAD which is 27.90. Mean Square Deviation (MSD); measures the accuracy of the fitted time series values. Outliers have a greater effect on MSD which is 1001.77.

3.3 Factors that affect maternal and infant mortality

Factors that affect maternal and infant mortality are considered in the regression analysis below. These factors considered are unemployment rate of the women, educational attainment, labor force participation rate, smoking prevalence and prevalence of undernourishment.

Exploratory Data Analysis of Maternal and Infant Mortality

Table 3: Regression coefficients for maternal mortality Rate

Term	β	$s.e(\beta)$	$t-value$	$p-value$
Constant	-210	1350	-0.16	0.878

Unemployment	-37.58	6.56	-5.73	0.000
Educational attainment	-439.7	48.0	-9.15	0.000
Labor force participation rate	-3194	618	-5.17	0.000
Smoking prevalence	3624	646	5.61	0.000
Prevalence of undernourishment	-1.05	1.10	-0.96	0.355

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
13.5424	98.71%	98.25%	96.52%

Table 3 above shows that Unemployment, Educational attainment, Labor force participation, and Smoking prevalence rate are significant to the model while Prevalence of undernourishment rate is not significant to the model at 5% level of significant. The model summary produces 98.71% for the R-square and 98.25% for the adjusted R square estimates which indicates that the response variable strongly explained the predictor variables. Therefore, the fitted regression model can be written as:

Maternal *Mortality* rate = -210-37.58Unemployment-439.7Educational attainment-3194Labor force participation rate+ 3624Smoking prevalence-1.05Prevalence of undernourishment

Table 4: Regression coefficients for Infant mortality

Term	β	$s.e(\beta)$	$t-value$	$p-value$
Constant	170	195	0.87	0.398
Unemployment	-3.393	0.945	-3.59	0.003
Educational attainment	-38.98	6.93	-5.62	0.000
Labor force participation rate	-220.1	89.2	-2.47	0.027
Smoking prevalence	254.2	93.1	2.73	0.016
Prevalence of undernourishment	0.105	0.158	0.66	0.518

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.95322	97.61%	96.76%	95.16%

Table 4 above shows that Unemployment, Educational attainment, Labor force participation rate, and Smoking prevalence rate are significant to the model while Prevalence of undernourishment

rate is not significant to the model at 5% level of significant. The model summary produces 97.61% for the R-square and 96.76% for the adjusted R square estimates which indicates that the response variable strongly explained the predictor variables. Therefore, the fitted regression model can be written as:

Infant Mortality rate = 170-3.393Unemployment-38.98Educational attainment-220.1Labor force participation rate+ 254.2Smoking prevalence+0.105Prevalence of undernourishment

4. Conclusion

The United Nations Millennium Development Goals (MDGs) have 8 goals that UN Member States agreed to try to achieve by the year 2015. Amongst which are Development goals 4 (reduce child mortality) and 5 (improve maternal health). The MDGs didn't really meet their proposed target, so the MGDs were succeeded by the SDGs (sustainable development goals). The SDGs 3 encompasses both Maternal and Neonatal deaths as: Good health and well-being. Despite the global progress on reducing maternal and infant mortality, most countries were not able to meet up with the target of MDGs4 and MDGs5 in which Nigeria is included. There are still a lot to be put in places to improve the maternal health in order to eradicate the deaths of babies and women within the reproductive ages.

However, our study aimed at determining the factors that affects infant and maternal mortality and also to examining the causes of infant and maternal mortality in Nigeria. This study examines the demographic data of infant and maternal mortality in the region using the structured and validated data, the descriptive statistics shows that the standard error of infant and maternal mortality are 2.43 and 22.9 respectively while their skewness are 0.64 and 0.78 respectively which means the distribution of the data is fairly symmetrical. The time plot for both infant and maternal mortality between 2000 and 2019 exhibiting a downward and gradual decreasing trend respectively over the considerable years. The model produces forecast performance with accuracy measures of MAPE, expressing accuracy as a percentage of the error with 2% and 3% for both infant and maternal mortality. The exploratory data analysis (EDA) of infant and maternal mortality under the study shows that Unemployment, Educational attainment, Labor force participation, and Smoking prevalence rate are significant to the model while Prevalence of undernourishment rate is not significant to the model at 5% level of significant. Therefore, prevalence of undernourishment rate is the major factor affecting the death of the child and mother at the child birth. Hence, to achieve the SDG 3 'the mothers and child at child birth, we recommend that government must be able to effect and improve antenatal care overtime by empowering families and communities to reduce infant and maternal deaths.

References

Alhassan A., Cesia C., Sheila A. O, Haruna M., and Emily R.S, (2021). Timing and causes of neonatal mortality in Tamale Teaching Hospital, Ghana: A retrospective study. PLoS ONE 16(1), 891–900.

Bustreo F, Say L, Koblinsky M, Pullum T W, Temmerman M., and others. (2013). Ending Preventable Maternal Deaths: The Time Is Now. The Lancet Global Health 1 (4): E176–77.

Gilmore K, and Camhe Gebreyesus T A. (2012). What Will It Take to Eliminate Preventable

Maternal Deaths? The Lancet 386 (9837): 87–88.

Imtiaz Jehan, Hillary Harris, Sohail Salat, Amna Zeb, Naushaba Mobeen, Omrana Pasha, Elizabeth M McClure, Janet Moore, Linda L Wright & Robert L Goldenberg (2009). Neonatal mortality, risk factors and causes: a prospective population-based cohort study in urban Pakistan. Bull World Health Organ 87,130–138.

Lavrakas J.P. (2008). Trend Analysis- SAGE Research Methods.

Lawn J.E, Cousens, S., and Zupan J. (2005). 4 million neonatal deaths: When? Where? Why?

Lancet. 365(9462):891–900.

Najlaa I M Al-Sammak and Humam G I Zubeer (2018). Trends of Maternal Mortality in Nineveh (2004-2013), A Time Series Analysis. Ann Coll Med Mosul, Vol 40 (2): 41-47.

Sagger, R., Kongnyuy, E., Adebimpe, W.O, Omosehin O., Ogunsola, A.E., and Sanni, B. (2019). Causes and contributory factors of maternal mortality: evidence from maternal and perinatal death surveillance and response in Ogun state, Southwest Nigeria. BMC pregnancy and childbirth, 19(1), 63

Say L, Chou D, Gemmill A, Tuncalp O, Moller A-B., Daniels, J. Gulmezoglu A.M., Temmerman, M. and Alkema, L. (2014). Global Causes of Maternal Death: A WHO Systematic Analysis. The Lancet Global Health 2 (6): e323–33.

Website of the Open Working Group on Sustainable Development Goals at http: //sustainabledevelopment.un.org/owg.html.

World Health Organization (2014). Reproductive Health and Research. Vol 6

WHO, UNICEF, UNFPA, The World Bank, United Nations Population Division. Trends in maternal mortality: 1990 to 2015. Geneva: Report 2015

World Health Organization, UNICEF, UNFPA, The world Bank, United Nations Population Division. Trends in maternal mortality: 1990 to 2013. Report 2014.

UNICEF, World Health Organization, World Bank, United Nations. Levels and trends in child mortality. Report 2019.