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Modified Effect of Demographic Factrs on Infant and Child Mortality

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ABSTRACT
Infant and child mortality is a powerful indicator to measure the health and social status of a country. The aim of the study is to use a modified logistics regression on the effect of infant and child mortality rate through the following objectives identify the major factors leading to infant and child mortality rate and to fit a modified logistic regression model on the incidence of infant and child mortality rate given the risk factor. To achieve this aim, the data obtained in the study was analyzed and computed using descriptive statistics and modified logistics regression model. A total of 250 questionnaires were retrieved out of 300 questionnaires administered on 300 respondents. Demographic, socioeconomic status and environmental factors of respondents obtained from the field. The software packaged that has been used to process data is SPSS version 21. The variables considered in the primary data source include while the Economic factors considered are Education of a mother, education of a father, occupation of mother, and marital status of mother whereas the environmental factors considered are antenatal clinic, place of delivery, health facility, child's immunization status and beneficiary of NHIS. the test of independence between the dependent variable (mortality) and independent variable (age, sex, occupation of the father, occupation of mother, education status of the father, education status of the mother, age of the mother, types of breast feeding, immunization status, marital status of mother birth interval, antenatal care, health facility type of diseases and beneficiary of NHIS) was performed to verify whether they are statistically significant or not at 5% level of significance to the infant and child mortality. A modified logistic regression model containing all the predictor variable was fitted. The finding of the study shows that birth interval, non-exclusive breast feeding, mothers' education, antenatal care, use of child vaccine, type of disease, child immunization and health facility have statistically significant effect on infant and child mortality.

Keywords: *Mortality, Multiple Logistic, Demographic, Socio Economic, Environmental, Infant and Child mortality analysis*

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I. INTRODUCTION

Mortality (Death) according to World Health Organization (W.H.O) is the absence of all traces of life at any time after birth. These can also be referred to as non-functionality of all parts or the whole body after birth. Mortality is the risk of dying in a given year, measured by death rate. In the entire universe, lately, there are thousands of people that die due to one cause or the other. If these causes of death are not noticed, recognized and given proper attention, we may not know the exact causes of various deaths per hour. The best way to do this and make recommendation is to apply statistical techniques to extract the information as it relates to the population or sample of interest.

Death of children under five years of age is a factor that defines the well-being of a population and it is usually taken as one of the development indicators of health and socio-economic status which indicate the quality of life of a given population, as measured by life expectancy. That is why reduction of infant and child mortality is a worldwide target and one of the most important key indices among Millennium Development Goals (MDGs), in reducing infant and under-five child mortality rates by two-thirds from the 1990 levels by 2015 [7]. As a result of this, in October 2008, the Nigerian government 's National Health Insurance Scheme (NHIS) launched a pilot health project, titled the NHIS/MDG Maternal and Child Health Project (hereafter referred to as the Project). The Project focuses on reducing maternal and child mortality and uses funds from the World Bank's heavily Indebted Poor Countries Initiative (HIPC), which provides dollar-for-dollar debt reduction against government allocation of funds to poverty-reduction programs. Nigeria's Office of the Presidency/Millennium Development Goals (MDGs) in coordination with the NHIS, Nigerian Congress, and Ministry of Health designed the Project to leverage HIPC support in the fight against maternal and child mortality. Infant mortality has become more prevalent due to lack of access to health care before, during and after delivery. This contributes to high infant mortality rates both in developing and under-developed country[17].

Every day, Nigeria loses about 2,300 under-five year olds and 145 women of child-bearing age, making the country the second largest contributor to under-five and maternal mortality rate in the world. Many lives can be saved if global inequalities are reduced[16]. The fertility rates also vary across countries. General Fertility Rates (GFR) and Infant Mortality Rates (IMR) are higher in low-income countries. Assuming that higher GDP-per capita and/or lower share of agricultural labour force in total labour force are an index of economic development, we can argue that both general fertility rate (GFR) and infant mortality rate (IMR.) decline with economic development. Similarly, GFR and IMR. are higher where social indicators like literacy and availability of health services are low.

Though global under-five mortality rates declined by 59 percent from 93 deaths per 1,000 live births in 1990 to 38 in 2019, it still remains a major health challenge in developing countries, especially Africa that is often faced with the problems of economic crisis, corruption, poor infrastructure, and a weak healthcare system.

According to UNICEF, sub-Saharan Africa remains the region with the highest under-five mortality rates globally. In 2019, the average under-five mortality rate in the region was 76 deaths per 1,000 live births. Within the region, Nigeria has one of the highest under-five mortality rates of 117 per 1,000 live births. This means that 1 in 8 children die before the age of 5, and this is worse than the global average of 1 in 13 children which was achieved over two decades ago.

The infant mortality rate, is the number of deaths in the first year of life per 1,000 live births, is a widely used indicator of population health and well-being. Infant mortality generally is defined as deaths before the reaching the first year of life. Usually one of the main indicators and most widely used for assessing health status of a population is infant mortality rate per 1000 live births. It is believed that the infant mortality is reflected an improper child care and is also closely associated with well-being in a given regions or country [3]. This is demonstrated that factors affecting on health status in a given country could be impact on infant mortality in its community. Survival efforts can be effective only if they are based on accurate information of the cause of morbidity [1]. The role of ethnicity on under-five mortality in Nigeria has been established [2]. Among the various ethnic groups in Nigeria, high under-five mortality is associated with the Hausa ethnic group as a result of early motherhood, parity and short birth spacing. Besides, the non-use of contraceptive has been identified as a risk factor of under-five mortality in Nigeria. under-five mortality is correlated with geographical locations with high levels of insecurity such as the Boko Haram insurgency and banditry activities. This is in line with the assertion of [6] that insecurity in north-eastern Nigeria reduces the probability of antenatal care visit, delivery at a health center and delivery by a skilled health professional. However, from the above, there is scanty evidence on the economic predictors of under-five mortality in Nigeria from a geographical viewpoint. Existing studies on the economic predictors of under-five mortality globally can be divided into three major categories: the studies based on cross country analysis, state/region-specific analysis and country-specific studies (no disaggregation into state or region).

Many countries have shown considerable progress in tackling child mortality rate and it has been more than halved in Northern Africa, Eastern Asia, Western Asia, Latin America the Caribbean and Europe. It has placed them on track to achieving the (SDG) in contrast to many countries with unacceptably high rates of child mortality. Sub-Saharan Africa which accounts for 1/5th of the population of children under 5years, also accounts for half (8.8 million) of deaths in 2008 indicating insufficient progress to meet the SDG 2020 targetworld health organization (WHO, 2014). The United Nations Population Fund (UNFPA) (2019)[13] observes that Nigeria's population is 201 million, with average growth rate of 2.6 percent from 2010 to 2019, meaning that an average Nigerian woman gives birth to at least five children, against global 2.5 percent in 2019. The report states: Contraceptive prevalence rate among Nigerian women aged 15-49 is only19 percent, decision-making on sexual and reproductive health and reproductive rights among these women averaged 51 percent between 2007 and 2018.

Nikoloski and Amendah (2017)[9] examined the probability of increased health expenditure on health leading to a better health outcome on the populace in 14 African countries from 2002 to 2014, focusing on infant mortality, neonatal mortality, under-five mortality, and life expectancy at birth. The study employed descriptive and multivariate analyses, and their finding revealed that public health expenditure reduces infant, neonatal and under-5 mortality,

According to [8] high cases of under-five mortality were reported among women with no formal education in northern Nigeria. As noted by [24], women with no formal education have fewer medical consultations for their children when ill, which predisposes them to untimely death.

Child mortality rates are rapidly increasing as more infants are born with HIV and anthropogenic factors such as internal crises, malnutrition and climate change [10].

Infant and Child Mortality

Infant mortality is defined as the death of a live born infant between birth and exact age one (1) [12]. Infant mortality rate is the probability of a child born in a specific year or period dying before reaching the age of one, if subjected to current age specific mortality rates of that period. Infant mortality is a potentially important indicator. This is because mortality tends to decline more slowly among infants than among children aged 1 to 5. Child mortality includes deaths that occur at ages 1 to 5 years.

II. METHODOLOGY

This chapter focuses on the methods and data collection from the study area. It is necessary to critically study our methods and procedures as a precondition for achieving the desired goals. The research explored the prediction powers of the logistic model as regards to the proper applications of biomedical modeling and to compare same for classifying the infant and child mortality. The variables considered in this research are Age, marital status, mother education, mother occupation, birth interval, breastfeeding practice, antenatal care, use of child vaccine, type of disease, national health insurance scheme, child immunization status, health facility, father education, father occupation, used are going to be considered if they are actually the risk factors of infant and child mortality.

2.1. Logistic Regression Model

Binary Logistic deals with the binary case, where the response variable consists of just two categorical values. Logistic regression model is mainly used to identify the relationship between two or more explanatory variables (X_i) and the dependent variable (Y). Logistic regression model has been used for prediction and determining the most influential explanatory variables on the dependent variable (Cox and Snell, 1994). The logistic regression model is the most frequently used regression model for analysis. It is important to understand that the goal of an analysis using this model is the same as that of any other regression model used in statistics; that is, to find the best fitting and interpretable model to describe the relationship between an outcome (response) variable and a set of independent (explanatory) variables.

The generalized logistic model is given as:

$$Y_t = \ln\left[\frac{\pi(x_i)}{1-\pi(x_i)}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_{2+} \ldots + \beta_p x_p$$

This model explains the effects of the predictor variables on the response.

Where the response variable Y_t is binary, taking value of either 0 or 1.

$\beta_1, \beta_2, \ldots \beta_p$ representing the coefficients of the $x_{i's}$.

The significance of the model parameter is tested individually or in groups using the walds test statistics. a modification will be done for gender

Multiple Logistic Regression:

Logistic regression analysis is a widely used and popular analysis that is similar to linear regression analysis exception is that the outcome is dichotomous (e.g., died/lived or yes/no or success/failure). In Logistic regression analysis, we calculate the odds of an outcome, and by using the natural log of the odds of the outcome as the dependent variable, the relationships can be linearized and treated much similar as multiple linear regression.

Simple logistic regression analysis is the application of regression with one dichotomous outcome and one independent variable; on the other hand, in multiple logistic regression analysis, we apply single dichotomous outcome like as simple logistic regression but more than one independent variable.

The dichotomous outcome in logistic regression is usually coded as 0 or 1, where 0 indicates that the outcome of interest is absent, and 1 indicates that the outcome of interest is present. If we say π(X) represents the probability of an event that depends on p independent variables. Then, using an inverse logit formulation for modelling the probability, we have:

$$\pi(X) = \frac{e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}{1+e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}} \qquad (1.1)$$

To get the appropriate logit function from this, we calculate $X = (X_0, X_1X_2, \ldots, X_p); X_0 = 1)$:

$$\log \quad it[\pi(X)] = ln\left[\frac{\pi(X)}{1-\pi(X)}\right]$$

$$= ln\left[\frac{\dfrac{e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}{1+e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}}{1-\dfrac{e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}{1+e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}}\right]$$

$$= ln\left[\frac{\frac{e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}{1+e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}}{\frac{1}{1+e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}}}\right] \qquad (1.2)$$

$$= ln\left[e^{\beta_0+\beta_1X_1+\cdots+\beta_pX_p}\right]$$

$$= \beta_0 + \beta_1X_1 + \cdots + \beta_pX_p$$

$$= X\beta;\ where\ \beta = (\beta_0, \beta_1, \dots \beta_p)$$

Equation 1.1 provides the probabilities of outcome events given the covariate values $X = (X_0, X_1 X_2, \dots, X_p)$ and equation 1.2 shows how the logistic regression is a ordinary linear regression model, once we transform the dichotomous outcome by the logit transformation. This transformation changes the range of $\pi(X)$ from 0 to 1 to $-\infty$ to $+\infty$, as usual for linear regression.

2.1.1 Assumptions of the logistic regression model

Logistic Regression does not make many of the key assumptions of linear regression and general linear models that are based on ordinary least squares algorithms particularly regarding linearity, normality, homoscedasticity, and measurement level. (Anon., 2014)

These are the following key assumptions of Logistic Regression Model:

▪ Binary logistic regression requires the dependent variable to be binary.

▪ Logistic regression assumes that P (Y = 1) is a probability of the event occurring, it is necessary that the dependent variable is coded accordingly. That is the factor level 1 of the dependent should represent the desired outcome.

▪ The model should be fitted correctly. That is only the meaningful variables should be included. ▪ The model should have little or no multicollinearity.

▪ Logistic regression assumes linearity of independent variables and log odds.

▪Logistic regression requires quite a large sample size. Reliability of estimates declines as fewer observations are used.

2.1.2 Interpretation of the $\boldsymbol{\beta}$ coefficients in multiple logistic regression:

2.1.3 Interpreting the intercept, $\boldsymbol{\beta_0}$:

Setting all the covariate values to zero in equation 1.1 and 1.2, then we get the following equation 1.3 and 1.4 respectively.

$$\pi(X_o) = \frac{e^{\beta o}}{1+e^{\beta o}} \qquad (1.3)$$

$$\beta_0 = ln\left[\frac{\pi(X_0)}{1-\pi(X_0)}\right] = \ln[Odds(\pi(X_0))] \qquad (1.4)$$

Therefore, β_0 sets the "baseline" event rate, through the above function in 1.3 and 1.4, when all covariate values are set to zero.

2.1.4 Interpreting the slopes, $\boldsymbol{\beta_j; j = 1, 2, \dots, p}$:

Setting all the covariate values to zero in equation 1.2 except X_p, then we get the following equation 1.5.

$$ln\left[\frac{\pi(X_p)}{1-\pi(X_p)}\right] = \beta_0 + \beta_j = ln\left[\frac{\pi(X_0)}{1-\pi(X_0)}\right] + \beta_p$$

$$\Rightarrow \beta_j = ln\left[\frac{\pi(X_p)}{1-\pi(X_p)}\right] - ln\left[\frac{\pi(X_0)}{1-\pi(X_0)}\right] = ln\left[\frac{\frac{\pi(X_p)}{1-\pi(X_p)}}{\frac{\pi(X_0)}{1-\pi(X_0)}}\right] = ln(OR_p)$$

$$\Rightarrow e^{\beta_p} = OR_p \qquad (1.5)$$

Therefore, we see that the coefficient β_j is such that e^{β_j} is the ratio of $Odds\left(\pi(X_j)\right)$ to $Odds(\pi(X_0))$ for a unit change in X_j.

2.1.5 Estimation of the β coefficients for a data set:

The dichotomous dependent variable associated with logistic regression is distributed as Binomial. For n observations with covariate values $X_i = (X_{1i}, X_{2i}, \dots, X_{pi})$ $i = 1,2, \dots, n$ the likelihood function is:

$$\prod_{i=1}^{n} \pi(X_i)^{z^i}(1-\pi(X_i))^{1-z^i} \qquad (1.6)$$

To estimate the unknown β coefficients, we have to maximize this likelihood function. We use the usual steps, first taking the logarithm of the likelihood function, and then taking $(p+1)$ partial derivatives with respect to each $\beta_p; p = 0,1,2, \dots, p$ and setting these $(p+1)$equations equal to zero, to form a set of $(p+1)$ equations in $(p+1)$ unknowns. Finally, solving this system of equations, we get the ML estimate of βp's.

We omit the elaborate calculation as we get the maximum likelihood estimates of $\beta_p{'s}$ using statistical software. Inferences also depend on SE formulae for confidence intervals, and likelihood ratio test for hypothesis testings. we will omit the detail calculation, and we rely on statistical software.

Thus, the modified regression model will be g(x) = $\frac{e^{\beta_0} + e^{\beta_1 x_1} + \ldots + \propto_t}{1 + e^{\beta_0} + e^{\beta_1 x_1} + \ldots + \propto_t}$ Where $\propto_t$ stands for sex 1 = male, 2 = female

III. RESULT

Table 3.1: Frequency of demographic factors and socio-economic status on infant and child mortality

Variables	Categories	Frequency
Age	15 – 24	86
	25-34	121
	35 and above	43
Gender	Male	44
	Female	206
Birth interval of last child	Less than two years	49
	At least two years	61
	More than two years	140
Breastfeeding	Exclusive breastfeeding	143
	Not Exclusive	107
Marital Status	Single	56
	Married	159
	Widowed/ separated	35
Mothers Education	No education	58
	Basic	95
	Secondary	65
	Tertiary	32
Fathers education	No education	57
	Basic	34
	Secondary	124
	Tertiary	35
Mothers Occupation	Civil/Public servant	62
	Farmer	118
	Trading	24
	Unemployed	46
Fathers occupation	Civil/Public servant	77
	Farmer	129
	Trading	20
	Unemployed	24

Table 3.2: Frequency of Biological, and environmental Factors on infant and child Mortality

Variables	categories	Frequency
Antenatal Care	Yes	105
	No	145
Use of child vaccine	Yes	146
	No	90
Disease	Diarrhea	38
	Anaemia	17
	Malnutrition	116
	Malaria	63
	Pneumonia	60
Beneficiary of NHIS	Yes	117
	No	133
Child immunization status	BCG	63
	OPV1	43
	OPV2	55
	OPV3	36
	Measles	32
	Yellow Fever	11
Health Facility	Yes	103
	No	147

Table 3.3: Logistic regression with Estimated coefficients, standard errors, Wald's test and odds ratio with 95% C.I. of the best model on infant and child mortality

Variable	Estimated coefficient	Estimated std error	Wald's test	p-value	Exp(β)	95% C.I for Exp(β)	
						Lower	Upper
Age	3.442	0.229	7.529	1.042	-13.065	1.201	1.321
Gender	5.441	1.321	9.614	0.306	-7.203	3.114	20.112

Birth interval Less than two years	9.014	3.109	4.162	0.013	2.550	0.147	212.101
Non-Exclusive breastfeeding	4.221	3.104	3.551	0.011	9.873	2.190	43.132
Marital Status	2.643	0.772	2.997	0.119	-1.124	6.091	25.163
Mothers Education (No)	8.821	0.983	2.191	0.015	2.008	0.185	121.332
Fathers education	2.779	6.136	7.813	0.212	-0.031	0.108	99.173
Mothers Occupation	1.559	1.362	6.143	0.340	-2.503	0.772	287.110
Fathers occupation	0.645	5.185	3.316	0.511	-10.094	0.284	371.334
Antenatal Care (No)	3.997	1.849	5.221	0.007	8.660	0.749	54.676
Use of child vaccine (No)	1.538	0.779	1.649	0.019	7.440	1.173	33.109
Disease	7.042	2.223	0.112	0.009	5.430	0.321	37.125
Beneficiary of NHIS	4.412	6.917	3.007	0.431	-3.013	0.882	263.102
Child immunization (No)	1.227	9.240	0.227	0.021	1.417	0.991	721.200
Health Facility (No)	12.220	7.210	1.386	0.030	15.120	0.027	0.007
Constant	2.008	3.551	0.066	0.346	22.126	3.119	5.007

The model

$$g(x)= \frac{\left[e^{\beta_0}+ e^{\beta_1 x_1}+ . . .+ e^{(\beta x)t}\right] + \propto_t}{\left[1+ e^{\beta_0}+ e^{\beta_1 x_1}+ . . .+ e^{(\beta x)t}\right]+ \propto_t}$$

Where $\propto_t$ stands for gender 1=male 2=female

$$= \left[\frac{\left[exp^{\begin{matrix}(22.126-\beta_{1*13.1}+\beta_{2*2.5}-\beta_{3*1.1}+\beta_{4*2.0}-\beta_{5*0.0}+\beta_{6*2.0}-\beta_{7*10.1}+\beta_{8*8.7}+\beta_{9*7.4}+\beta_{10*9.9}\\ +\beta_{11*5.4}-\beta_{12*3.0}+\beta_{13*1.4}+\beta_{14*15.1}\end{matrix}}\right]- 7.203}{\left[1+ exp^{\begin{matrix}(22.126-\beta_{1*13.1}+\beta_{2*2.5}-\beta_{3*1.1}+\beta_{4*2.0}-\beta_{5*0.0}+\beta_{6*2.0}-\beta_{7*10.1}+\beta_{8*8.7}+\beta_{9*7.4}+\beta_{10*9.9}\\ +\beta_{11*5.4}-\beta_{12*3.0}+\beta_{13*1.4}+\beta_{14*15.1}\end{matrix}}\right]- 7.203}\right]$$

IV. DISCUSSION OF THE RESULT

The result above indicates that Birth Interval Less than two years, Non-Exclusive breastfeeding, Uneducated mother, mother that don't attend antenatal Care, no use of child vaccine, Disease, mother that don't attend heath facility, Child not immunized are more susceptible to lead to infant and child mortality while factors like Age, Marital Status, Fathers education, Mothers Occupation, father occupation, Beneficiary of NHIS, are not susceptible to lead to infant and child mortality. This implies that to determine or predict whether a child would die as an infant Birth Interval Less than two years, Non-Exclusive breastfeeding, Uneducated Mothers, mother that don't attend antenatal Care, no use of child vaccine, Disease, mother that don't attend health facility, Child not immunized could be relevant factors.

V. CONCLUSION

The study shows that various socio-demographic and health service covariates are significant determinants of infant and child mortality.

Accordingly, the finding of the study show that birth interval, non-exclusive breast feeding, mothers' education, antenatal care, use of child vaccine, type of disease, child immunization and health facility have statistically significant effect on infant and child mortality

For instance, children born to mothers with higher educational level associated with lower risk of infant and child mortality as compared to children born to mothers with primary education level or non-educated as well as the age of the mother also contribute to the mortality of the infant and child. The marital status, birth interval, non-exclusive breast feeding, antenatal care, use of child vaccine, type of disease, child immunization and health facility have statistically significant effect on infant and child mortality.

The parent should endeavor to be educated, early marriage should be reduced and the parent should try to practice exclusive breast feeding so as to reduce the rate of infant and child mortality.

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