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## Cox Survival Modeling of Neonatal Mortality in Nigeria

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### ABSTRACT

Nigeria continues to have one of the highest rates of neonatal deaths in Africa. This study investigates risk factors associated with neonatal deaths in Nigeria adopting the 2013 Nigeria Demographic and Health Survey (NDHS). Neonatal deaths of all singleton live-born infants were extracted from the 2013 NDHS. The 2013 NDHS was a multi-stage cluster sample survey of 38, 948 households. Of these households, complete cases of 1443 survival information were extracted including 879 cases of neonatal mortality. Using the traditional Cox Regression model, Significant factors that affected neonatal deaths were: mother's level of education, residence type, size of the child, sex of the child, timing of breastfeeding initiation and number of antenatal visits. The study suggests that the Nigerian government needs to invest more in the healthcare system to ensure quality care for women and newborns to reduce avoidable neonatal deaths in Nigeria.

**Keywords:** Neonatal, Risk factors, Mortality, Cox Regression.

### Introduction

Neonatal mortality is the demise of an infant short of one month of age; it is measured as Neonatal Mortality Rate (NMR) which is the number of death of infants under one month of age for each 1000 live births around the same time.

Neonatal mortality is still a noteworthy general wellbeing issue around the world, and records for more than 60% of infant deaths before their first birthday (UNICEF, 2014). Of the world's 7.7 million deaths in those matured more youthful than 5 years, 3.1 million happened after birth through to 1 month of life (neonatal death). Almost 99% of these neonatal deaths happen in low-and center wage nations, generally in sub-Saharan Africa, including Nigeria. The larger parts of these deaths are brought about by preventable or treatable ailments, for example, irresistible

illnesses, which add to roughly 36% of these deaths. Past studies have demonstrated that the worldwide decrease in neonatal death rates has been slower contrasted and newborn child and under-5 year old death rates, particularly in the sub-Sahara African district (Akinyemi *et al.*, 2015).

The baby's danger of biting the dust is most noteworthy in the neonatal period, safe labor and productive neonatal considerations are crucial to keep these deaths. Around 45% of deaths of children less than 5 years old happen amid the neonatal period. About 2.7 million Babies kick the bucket each year in their first month of life and comparable numbers are still conceived, inside the initial 24 hours of life and 75% happen in the primary week.

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The 48 hours instantly taking after the birth is the most vital period for new conceived survival. This is the place the mother and child get follow up consideration to counteract and treat sickness.

Nigeria's push to diminish under-five mortality has been one-sided for childhood mortality to the disregard of neonates and there is inadequate published literature on the determinants of neonatal mortality. Though studies have shown that about a large portion of newborn child deaths happen in the neonatal period. Along these lines, this study was led to recognize the socio-demographic and maternal and child care components connected with neonatal mortality in Nigeria.

**MATERIALS AND METHODS**

**Data Description**

The data for this study was extracted from the Nigeria Demographic Health Survey Data (NDHS) for 2013. However, it suffices to state that the NDHS were based on nationally representative sample of women aged 15-49 years and men aged 15-59 years who were selected using a stratified two-stage cluster sampling technique (NDHS, 2013).

The outcome is the risk of neonatal death. Infant mortality is defined as the death of a child before completing one month of age. Therefore, time to death was measured in days and infants who lived beyond 28 days were censored at that time for the purpose of survival analysis.

**METHODOLOGY**

Firstly, we carried out a preliminary analysis on the comparison of survival experiences with respect to some selected background, maternal and child care characteristics by fitting Kaplan-Meier curves and performing log-rank tests.

Let  $S(t) = \Pr (T > t)$  be the survival function, i.e. the probability of a child surviving beyond time  $t$  (Kleinbaum and Klein, 2005). Also, let  $j=1,2, \dots, J$  be the distinct times of observed events in either group. For each time  $j$ , let  $N_{1j}$  and  $N_{2j}$  be the number of subjects at risk at the start of period  $j$  in the two groups respectively. Let  $N_j = N_{1j} + N_{2j}$  and let  $O_{1j}$  and  $O_{2j}$  be the observed number of events in the groups respectively at time  $j$ , and define  $O_j = O_{1j} + O_{2j}$ . The log-rank statistic is distributed  $\chi^2$  with  $G-1$  degrees of freedom, where  $G$  is the number of groups.

$$E_{1j} = \frac{O_j}{N_j} N_{1j} \text{ and Variance } V_j = \frac{O_j (N_{1j} / N_j) (1 - N_{1j} / N_j) (N_j - O_j)}{N_j - 1}$$

$$\text{Let } h(t) = \frac{\lim_{\Delta t \rightarrow 0} \Pr \left[ \frac{\text{an individual fails in the time interval } (t, t + \Delta t)}{\text{given the individual has survived to } t} \right]}{\Delta t}$$

It can also be written mathematically as:

$$h(t) = \lim_{dt \rightarrow 0} \frac{\Pr \{ t \leq T < t + dt | T \geq t \}}{dt}$$

Let  $X_i$  be observed covariates. The standard approach for analyzing the impact of the covariates on the survival times is the Cox proportional hazard model, where the multiplicative structure

$$h(t, \mathbf{X}) = h_0(t) e^{\sum_i^p \beta_i X_i}$$

is assumed for the hazard rate. In the equation above,  $\beta_i$  is a vector of regression coefficients and  $h_0(t)$  is the baseline hazard rate and the estimation of the regression coefficients is based on the partial likelihood. This model is, however, based on the proportional hazard assumption.

The observed covariates in this study are classified into background characteristics, such as the mother's region of residence, resident type, sex of the child, birth order, highest educational level of mother, size of child at birth, wealth index, Place of delivery, delivery type, age at birth and maternal and child care characteristics, such as Antenatal care, timing of breastfeeding, drinking water source and type of toilet facility. These variables have been selected as suggested by the medical and epidemiological literature to have a significant contribution to the survival or death of infants.

## ANALYSIS AND RESULTS

The Kaplan- Meier curve was plotted to describe the survival probabilities of the children and to compare the survival experiences for some selected background characteristics of the mother. The log-rank test was used to test the hypothesis of no difference between groups of each selected background characteristics of the mother.

Cox-Proportional Hazard Model was fitted to assess the importance of various covariates on the survival times of neonates through their hazard ratios.

Table I shows the frequency distribution of some selected factors with respect to some factors affecting survival of infants in Nigeria.

Of the 38948 households surveyed in the data set used in this study, complete cases of only 1443 survival information were extracted including 879 cases of neonatal mortality. About half of them (43.7%) had no education, while the remaining had at least a primary school education.

Also, about half of them (47.7%) were poor, while the remaining were either average or rich in terms of wealth index. Weight of the child were evenly distributed as 37.7% of them had babies of large weight, 39.8% of them had average while the remaining 22.5% had babies of small weight.

Sex of the child was also evenly distributed as 50.7% and 49.3% were male and female babies respectively. More of the children domiciled in the rural areas (56.7%), while the remaining 43.3% lived in the urban areas. Despite that timing of breastfeeding initiation for a baby is very important and key to his survival and wellbeing, majority of the respondents (65.3%) delayed breastfeeding while the remaining 34.7% did not.

**TABLE I: Frequency Distribution of Selected Background Characteristics with respect to Survival Status**

VARIABLES	STATUS		Total
	Alive	Dead	
<b>REGION</b>			
North Central	84 (46.4%)	97(53.6%)	<b>181 (12.5%)</b>
North East	86(31.7%)	185(68.3%)	<b>271(18.8%)</b>
North West	205(43.2%)	269(56.8%)	<b>474(32.8%)</b>
South East	73(43.2%)	96(56.8%)	<b>169(11.7%)</b>
South-South	65(33.9%)	127(66.1%)	<b>192(13.3%)</b>
South West	51(32.69)	105(67.3%)	<b>156(10.8%)</b>
<b>HIGHEST EDU. LEVEL</b>			
No education	269(42.6%)	362(57.4%)	<b>631(43.7%)</b>
Primary	107(40.2%)	159(59.8%)	<b>266(18.4%)</b>
Secondary	148(33.4%)	295(66.6%)	<b>443(30.7%)</b>
Higher	40(38.8%)	63(61.2%)	<b>103(7.1%)</b>
<b>WEALTH</b>			
Poor	283(41.1%)	405(58.9%)	<b>688(47.7%)</b>
Middle	116(38%)	189(62%)	<b>305(21.1%)</b>
Rich	165(36.7%)	285(63.3%)	<b>450(31.2%)</b>
<b>SIZE OF CHILD</b>			
Large	193(35.5%)	351(64.5%)	<b>544(37.7%)</b>
Average	230(40.1%)	344(59.9%)	<b>574(39.8%)</b>
Small	141(43.4%)	184(56.6%)	<b>325(22.5%)</b>
<b>SEX OF CHILD</b>			
Male	277(37.9%)	454(62.1%)	<b>731(50.7%)</b>
Female	287(40.3%)	425(59.7%)	<b>712(49.3%)</b>
<b>BREASTFEEDING TIMING</b>			
Immediately	153(30.6%)	347(69.4%)	<b>500(34.7%)</b>
Delayed	411(43.6%)	532(56.4%)	<b>943(65.3%)</b>
<b>ANTENATAL VISIT</b>			
No visit	263(41.8%)	366(58.2%)	<b>629(43.6%)</b>
Visit	301(37%)	513(63%)	<b>814(56.4%)</b>
<b>AGE AT BIRTH</b>			
0-19	43(38.4%)	69(61.6%)	<b>112(7.8%)</b>
20-34	245(38.2%)	396(61.8%)	<b>641(44.4%)</b>
35 and above	276(40%)	414(60%)	<b>690(47.8%)</b>
<b>DELIVERY TYPE</b>			
Normal	436(39.4%)	672(60.6%)	<b>1108(76.8%)</b>
Caesarean section	128(29.4%)	207(70.6%)	<b>435(23.2%)</b>
<b>PLACE OF DELIVERY</b>			
Home	355(40.4%)	523(59.6%)	<b>878(60.8%)</b>
Hospital	209(37%)	356(63%)	<b>565(39.2%)</b>
<b>DRINKING WATER</b>			
Not improved	299(39.6%)	457(60.4%)	<b>756(52.4%)</b>
Improved	265(38.6%)	422(61.4%)	<b>687(47.6%)</b>
<b>TOILET FACILITY</b>			
Not improved	311(39.4%)	479(60.6%)	<b>790(54.7%)</b>
Improved	253(38.7%)	400(61.3%)	<b>653(45.3%)</b>
<b>RESIDENCE TYPE</b>			
Urban	266(42.6%)	359(57.4%)	<b>625(43.3%)</b>
Rural	298(36.4%)	520(63.6%)	<b>818(56.7%)</b>

Table II shows a summary of the covariates used for the study based on the log rank test. In terms of the socio-economic and health care factors, the results show a significant difference in the probability of survival for neonates with respect to educational attainment, type of residence, Antenatal visits and Region.

**TABLE II: Summary of the selected factors based on the Log-rank test**

FACTOR	Log-Rank Statistic	Degrees of Freedom	p-value
Child Sex	1.1	1	0.292
Region	25.2	5	0.000125
Residence Type	5.5	1	0.0185
Educational attainment	18.3	3	0.000388
Wealth Index	5.6	2	0.0612
Child Size	2.7	2	0.265
Breastfeeding timing	0.0001	1	0.983
Antenatal visit	9.0	1	0.00271
Age at birth	0.3	2	0.84
Type of delivery	0.0001	1	0.973
Drinking water source	0.4	1	0.55
Toilet facility	0.2	1	0.634

The results of Cox hazard regression for factors associated with neonatal mortality are presented for the 2013 NDHS data (see Table III). There were differences in the risk of neonatal deaths across in a number of those factors.

**TABLE III: Cox Proportional Hazards Model of Neonatal Mortality**

<b>FACTOR</b>	<b>HAZARD RATIO</b>	<b>95% Confidence Interval</b>
<b>Child Sex</b> Male Female (Ref)	1.1	1.09 – 1.70*
<b>Region</b> North Central North West North East South South South East South West (Ref)	0.80 1.21 1.10 0.94 1.17	0.66 - 1.22* 0.95 - 1.17 0.84 - 1.45* 0.68 – 0.92 0.84 - 1.63
<b>Residence Type</b> Urban Rural (Ref)	0.77	0.65 - 0.91*
<b>Educational attainment</b> No Education (Ref) Primary Secondary Higher	1.09 0.78 0.65	0.90 - 1.32* 0.66 - 0.91* 0.60 - 0.93*
<b>Wealth Index</b> Poor (Ref) Middle Rich	1.21 1.35	1.26 – 1.35 1.20 – 1.31
<b>Child Size</b> Small Medium Large (Ref)	2.63 1.16	2.19 - 3.16* 0.98 - 1.38*
<b>Breastfeeding timing</b> Immediate Delayed (Ref)	0.74	0.70 – 0.81*
<b>Antenatal visit</b> None (Ref) At least One	0.65	0.44 – 0.68*
<b>Age at birth</b> <= 19 years (Ref) 20-34 years Above 35 years	1.22 1.31	1.25 – 1.33 1.30 – 1.40
<b>Type of delivery</b> Caesarean Normal (Ref)	0.97	1.09 – 1.17
<b>Drinking water source</b> Improved Not Improved (Ref)	0.94	0.96 - 1.09
<b>Toilet facility</b> Improved Not Improved (Ref)	0.88	1.06 - 1.08

Note: \* means Hazard ratio is contained in the 95% confidence interval and the corresponding variable is significant

#### 4. DISCUSSION

Various variables have been distinguished to be altogether connected with neonatal mortality, and each of these components is talked about beneath.

The study demonstrated that male neonates had an altogether higher danger of biting the dust amid the neonatal period contrasted with the female neonates. This finding is reliable with a cross-sectional study led in Indonesia in 2008, which demonstrated that male neonates will kick the bucket than female neonates (Titaley *et al.*, 2008). Moreover, a cross-sectional study performed in Bangladesh in 2011 reported a lower relative danger for female neonates contrasted and male neonates (Mostafa, 2011). An expanded danger of biting the dust in the primary month of life among male neonates might be ascribed to high helplessness to irresistible infection (Kassar *et al.*, 2013). Another conceivable explanation behind the low rate of neonatal deaths among young ladies might be a direct result of the improvement of early fetal lung development in the main week of life, bringing about a lower frequency of respiratory infections in female neonates contrasted and male neonates. All inclusive, it is assessed that around 23% of infant deaths are credited to respiratory issues (WHO, 2008).

In our study, mothers whose infants were perceived to be little or small had thrice more serious danger of passing on in the principal month of life than those mothers whose children are of a bigger size. Correspondingly, discoveries from a cross-sectional study led in five Asian nations (India, Indonesia, Nepal, Bangladesh, and the Philippines) in 2008 likewise demonstrated that littler than normal neonates had an expanded danger of neonatal deaths than normal or bigger measured neonates in four of the five nations with data on perceived infant size (Fort *et al.*, 2008).

Our study demonstrated that there was no significant relationship between method of conveyance (Cesarean or Vaginal) and neonatal mortality. The reverse is the case for a recent study on cesarean segment and perinatal mortality in South Western, Nigeria, which found that almost 84% of early neonatal deaths, happened in pregnant mothers who conveyed their infants by crisis cesarean segment (Ezechi *et al.*, 2009).

Our outcomes uncovered no significant relationship between maternal age and neonatal mortality. Our investigation is steady with cross-sectional studies directed in Swaziland and Tanzania, which found no noteworthy relationship between maternal age and neonatal mortality (Zwane, 2007, Ajaari *et al.*, 2012). Be that as it may, this finding is not predictable with was accounted for in a past studies.

The present study demonstrated that neonates born by mothers living in rural zones had a higher danger of neonatal mortality contrasted and those living in urban areas. This finding is reliable with past studies (Zwane and Masango, 2007), which credited this finding to constrained access to wellbeing offices and maternal social insurance administrations, for example, conveyance helped by a medicinal services proficient, and pre-birth and postnatal consideration. This disproportionally thwarts rural inhabitants from getting satisfactory social insurance administrations, bringing about a high likelihood of neonatal demise. In Nigeria, as in numerous developing nations, the dominant part of all around prepared doctor's facilities and wellbeing focuses are normally situated in urban territories.

As regards timing of breastfeeding start, our discoveries uncovered that mothers who started breastfeeding of their children inside the main hour of birth were more averse to encounter neonatal mortality than the individuals who delay breastfeeding. Likewise, there is

significantly higher chance for a mother had no less than one antenatal visit not to encounter neonatal mortality contrasted with the individuals who had none. The way that antenatal consideration stayed noteworthy in its defensive impact underscores the significance of value maternal watch over neonatal survival. A considerable amount of infant survival intercessions, for example, wellbeing training/directing, micronutrients supplementation, fetal checking, lockjaw toxoid infusion and others are given amid antenatal consideration. This outcome concurs with past discoveries which demonstrated that neonatal survival is naturally connected with appropriate maternal social insurance administrations (Akinyemi *et al.*, 2013). Household environmental variables (drinking water source and toilet facilities) were not significant in the fitted model. These variables have however been appeared to be critical for newborn child and under-five mortality (Fayehun, 2010).

### Conclusion

Our investigation of components connected with neonatal mortality in Nigeria revealed that

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living in rural areas, sex of the infant (being male), cesarean delivery, child's weight being little, number of antenatal visits and timing of breastfeeding start altogether expanded the danger of neonatal deaths. These components discovered connected with neonatal mortality are like those reported for other creating nations. Regardless of these known elements, adequate advancement has not been recorded in neonatal survival in Nigeria. Our discoveries demonstrate the need to actualize group based infant care mediations especially, teaching group wellbeing specialists and conventional birth chaperons about safe delivery rehearse. This Community-construct intercession ought to likewise center with respect to tyke dispersing, childbearing at a more youthful age, especially in rural zones, to lessen avoidable neonatal deaths in Nigeria.

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