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# INFANT MORTALITY, A CONTINIUING SOCIAL PROBLEM IN NORTHERN NIGERIA: COX REGRESSION APPROACH

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## ABSTRACT

**Background:** Over the last two decades, infant and child survival has remained a top global priority. In an effort to reduce child mortality, massive investment has been made to improve access to health-care, nutrition, hygiene and sanitation, and promote exclusive breastfeeding. As a result, all regions of the world have shown reductions in under-five and IMR. However, these achievements are challenged by disparities that persist among regions and within countries. **Objective:** To examine the determinants of Infant Mortality and Post-neonatal Mortality in Northern Nigeria. **Materials and Methods:** Secondary data sourced from the 2013 Nigeria Demographic and Health Survey was used, the study utilized survival analysis technique, basically Cox Regression analysis. **Results and Conclusion:** Analytical findings reveals that maternal age, birth order/preceding birth interval and source of drinking water are significantly related to post-neonatal mortality in Northern Nigeria. Also, occupation of the mother, birth order/preceding birth interval and source of drinking water were found to be significantly related to infant mortality in Northern Nigeria.
***Keywords:*** *Post-neonatal Mortality, Survival Analysis, Cox's proportional hazards model, Northern Nigeria, Neonatal Infection, Malnutrition.*

## 1. INTRODUCTION

Infant mortality is the death of a child less than one year of age. It is measured as infant mortality rate (IMR), which is the number of deaths of children under one year of age per 1000 live births. The leading causes of infant mortality are birth asphyxia, pneumonia, term birth complications, neonatal infection, diarrhea, malaria, measles and malnutrition [1]. Many factors contribute to infant mortality such as the mother's level of education, environmental conditions, and political and medical infrastructure. Improving sanitation, access to clean drinking water, immunization against infectious diseases, and other public health measures could help reduce high rates of infant mortality. Forms of infant mortality: Perinatal mortality is late fetal death (22 weeks gestation to birth), or death of a newborn up to one week postpartum [2]. Neonatal mortality is newborn death occurring within 28 days postpartum. Neonatal death is often attributed to inadequate access to basic medical care, during pregnancy and after delivery. This account for 40–60% of infant mortality in developing countries [3], and Post neonatal mortality is the death of children aged 29 days to one year. The major contributors to post neonatal death are malnutrition, infectious disease, and problems with the home environment. Leading causes of congenital infant mortality are malformations, sudden infant death syndrome, maternal complications during pregnancy, and accidents and unintentional injuries [4]. Environmental and social barriers prevent access to basic medical resources and thus contribute to an increasing infant mortality rate; 99% of infant deaths occur in developing countries, and 86% of these deaths are due to infections, premature births, complications during delivery, and perinatal asphyxia and birth injuries [2]. Greatest percentage reduction of infant mortality occurs in countries that already have low rates of infant mortality [5]. Infant mortality level is a measure of how well a society meets the needs of its people especially newborns, infants and pregnant women [6], Infant mortality is the most sensitive indicator of population health. High infant mortality rate (IMR) reflects the presence of unfavorable social, economic, and environmental conditions during the first year of life [7,8,9,10]. The MDG-4 calls for reduction in under-five mortality by two-thirds between 1990 and 2015 [10]. In 2013, infant mortality contributed to 73 % all under-five deaths [10]. Over the last two decades, infant and child survival has remained a top global priority. In an effort to reduce child mortality, massive investment has been made to improve access to health-care, nutrition, hygiene and sanitation, and promote exclusive breastfeeding [9-10]. As a result, all regions of the world have shown reductions in under-five and IMR [9-10]. However, these achievements are challenged by disparities that persist among regions and within countries [10]. The least developed countries and disadvantaged populations continue to bear the heaviest burden of infant deaths. In 2012, the global IMR was estimated as 35 per 1000 live births (LB), while it was 64 per 1000 LB in Sub-Saharan Africa [10]. Similarly, Sub-Saharan Africa has seen the least decline in IMR and under-five deaths [7-10]. Hence, this study aims to examine the determinants of Infant Mortality in Northern Nigeria, so as to establish their effect on the survival status of infants in these areas. Note, for the purpose of deeper understanding of the determinants of infant mortality, the investigation was expanded to include both post-neonatal and infant mortality.

## 2. MATERIALS AND METHOD

To achieve the set objectives, data pertaining the subject matter was obtained from the 2013 Nigeria Demographic and Health Survey (NDHS), and analyzed using the Statistical Package for Social Sciences for windows version 21. The study sample was based on 4,500 live births between the years 2010 to 2015, out of which 120 died in post-neonatal and 250 died in infant stages in the five-year period that preceded the survey. The study employed survival analysis, basically Cox regression analysis, to examine the risk of death in infancy stages, measured as the duration of survival since birth in months. The analysis offers several regression models for estimating the relationship of continuous variables to survival times. Further, Cox's proportional hazards model accounts for censoring in the estimation of exposure time since it allows for the incorporation of both the censored and uncensored survival cases in the data set. Censored observations arise whenever the dependent variable of interest represents the time to a terminal event, and the duration of the study is limited in time. Thus, the infants who were still alive by the time of survey represent the censored events with those who were dead representing the uncensored events. Cox's proportional hazards regression model is given by:

$$h(t) = h_o(t) * \exp(\beta_1 x_1 + ... + \beta_1 x_1) \quad (1)$$

Where, *h (t)* is the hazard rate; ***$h_o(t)$*** is the baseline hazard, and $\beta_1 .... \beta_n$ are the associated coefficients for the respective cases ($x_1 .... x_n$).

Therefore,

$$\ln\{h(t)/ h_o(t)\} = (\beta_1 x_1 + ... + \beta_1 x_1) \quad (2)$$

Where, ***$\{h(t)/ h_o(t)\}$*** is the hazard ratio. The regression coefficient indicates the relative effect of the covariate on the hazard function. A positive coefficient, in this study, indicated a greater probability of the risk of infant death and a negative coefficient indicated a lesser risk of infant death. The hazard function makes it easy to calculate the relative risk of certain groups in relation to the reference categories by the exponentiation of the coefficient so as to obtain the odds ratio. Since the relative risk for the reference category is one, odds ratios greater than one indicate a greater relative risk of dying for the specified group with respect to the reference group whereas odds ratios less than one indicate a lesser risk. The analysis entailed estimation of four models. Model I looked at the relationships of post-neonatal mortality and infant mortality with socioeconomic and geographic factors. Model II looked at the relationships post- neonatal mortality and infant mortality with socioeconomic, bio-demographic and household environmental factors. Model III considered the same relationships with regard to geographic and bio-demographic factors; while Model IV incorporated all the variables so as to estimate the independent effect of each variable when other variables were controlled for. The results brought out a clear picture of the significant variables in the discussion of rural post-neonatal and infant mortality in Northern Nigeria.

## 3. RESULTS AND DISCUSSION

**Table 1:** The table presents the distribution of post-neonate and infant deaths based on selected covariates.

| **Variable Name** | Post-neonate | | Infant | |
|---|---|---|---|---|
| **Level of Maternal Education** | n = 120 | Percent | n = 250 | Percent |
| Primary | 80 | 66.67 | 151 | 60.40 |
| Secondary/Higher | 29 | 24.17 | 40 | 16.00 |
| None | 11 | 9.16 | 39 | 15.60 |
| **Occupation of the Mother** | | | | |
| Agriculture | 40 | 33.33 | 82 | 32.80 |
| Non-Agriculture | 45 | 37.50 | 84 | 33.60 |
| Not Working | 35 | 29.17 | 84 | 33.60 |
| **Wealth Index** | | | | |
| High | 28 | 23.33 | 41 | 16.40 |
| Low | 70 | 58.33 | 150 | 60.00 |
| Medium | 22 | 18.34 | 59 | 23.60 |
| **Maternal Age** | | | | |
| 20-34 | 88 | 73.33 | 180 | 72.00 |
| <20 | 7 | 5.83 | 16 | 6.40 |
| 35+ | 25 | 20.84 | 54 | 21.60 |
| **Source of Drinking Water** | | | | |
| Pipe/Tap | 30 | 25.00 | 48 | 19.20 |

| | | | | |
|---|---|---|---|---|
| Borehole | 12 | 10.00 | 35 | 14.00 |
| Well | 15 | 12.50 | 36 | 14.40 |
| Surface | 55 | 45.83 | 120 | 48.00 |
| Other | 8 | 6.67 | 11 | 4.40 |
| **Presence of Toilet Facility** | | | | |
| Presence | 70 | 58.33 | 155 | 62.00 |
| Absence | 50 | 41.67 | 95 | 38.00 |
| **Preceding Birth Interval** | | | | |
| 2-3 & ≥ 24 months | 26 | 21.67 | 52 | 20.80 |
| 2-3 & < 24 months | 14 | 11.67 | 29 | 11.60 |
| 4+ & < 24 months | 19 | 15.83 | 41 | 16.40 |
| 4+ & ≥24 months | 41 | 34.17 | 80 | 32.00 |
| First births | 20 | 16.66 | 47 | 18.80 |

In other to bring out the distribution of post-neonate and infant deaths based on the study variables, Descriptive analysis was done. Table 1 reveals that majority of deaths occurred to women who had primary educational qualifications, who were working in non-agricultural sectors and in low wealth quintile households. Bio- demographically, mothers aged 20-34 reported majority of deaths with teenagers reporting the least number of deaths. This can be a reflection of the a few teens in marriages as majority of them are still in schools at such ages. A high proportion of deaths were of order four and above and of at least two years preceding birth intervals. Based on household environmental factors, households with a toilet facility present and which use surface water experienced majority of deaths.

**Table 2:** The table presents the determinants of Post-Neonatal Mortality in Northern Nigeria.

| Variable Name | Model I | Model II | Model III | Model IV |
|---|---|---|---|---|
| **Level of Maternal Education** | | | | |
| Primary | 1.340 | 1.139 | | 1.228 |
| Secondary/Higher | 1.000 | 1.000 | | 1.000 |
| None | 1.868 | 0.650 | | 1.254 |
| **Occupation of the Mother** | | | | |
| Agriculture | 1.000 | 1.000 | | 1.000 |
| Non-Agriculture | 1.083 | 1.134 | | 1.020 |
| Not Working | 0.785 | 0.738 | | 0.770 |
| **Wealth Index** | | | | |
| High | 1.000 | 1.000 | | 1.000 |
| Low | 0.793 | 0.848 | | 1.098 |
| Medium | 0.785 | 0.952 | | 1.377 |
| **Maternal Age** | | | | |
| 20-34 | | 1.000 | 1.000 | 1.000 |
| <20 | | 0.873 | 1.154 | 0.815 |
| 35+ | | 1.091 | 1.613 | 1.262 |
| **Source of Drinking Water** | | | | |
| Pipe/Tap | | 1.000 | | 1.000 |
| Borehole | | 0.487* | | 0.455 |
| Well | | 0.364*** | | 0.267*** |
| Surface | | 0.544** | | 0.395*** |
| Other | | 0.666 | | 0.402 |
| **Presence of Toilet Facility** | | | | |
| Presence | | 1.000 | | 1.000 |
| Absence | | 1.474* | | 2.126** |
| **Preceding Birth Interval** | | | | |
| 2-3 & ≥ 24 months | | 1.000 | 1.000 | 1.000 |
| 2-3 & < 24 months | | 1.556 | 1.423 | 1.473 |
| 4+ & < 24 months | | 1.876* | 1.800 | 1.721 |
| 4+ & ≥24 months | | 1.249 | 1.116 | 1.159 |
| First births | | 1.044 | 0.901 | 1.046 |

* $\rho < 0.05$; ** $\rho < 0.01$; *** $\rho < 0.001$

From the analytical findings in Table 2, we see that in model I, only the socio-economic and geographic variables were included and bio-demographic and environmental variables left out, implying that none of the variable was significantly related to post-neonatal mortality. In model II, where all the variables except geographic were included, the findings showed that only one category of the birth order and preceding birth interval, the source of drinking water and presence of a toilet facility were statistically related to post- neonatal mortality. The higher order births with shorter preceding birth intervals of less than 24 months had a higher risk of death. The results in model II found post-neonates in the 4+/<24 months birth order/preceding birth interval to have a 0.98 higher chance of dying compared to those in the 2-3/ ≥24 months birth order/preceding birth interval at 0.05 level of significance. Further, contrary to expectations, with reference to source of drinking water, post-neonates in households which source well and surface water were 0.64 and 0.46 times respectively, less likely to die than those in households with piped/tapped water. Households with no toilet facility were 0.47 times more likely to experience a post-neonate death than those with a toilet facility. The results in model III where socio-economic and environmental factors were left out, no variable displayed any statistically relationship to post-neonatal mortality at 0.05 level. Findings in the full model indicated that the observed significant effect of birth order/preceding birth interval in model II did not re-appear in the full model as in the case of model III. But the strong effect of the source of drinking water in the rural areas persisted as in model III. In fact, the suppressed significance of the effects of the categories of well and surface water sources compared to piped/tapped water sources at 0.001 level of significance was observed in the full model. It is likely that the piped/tapped water in rural areas may reflect other issues other than living standards. Further, post-neonates in households with no toilet facility experience a more than double death risk compared to their counterparts in households with a toilet facility.

**Table 3:** The table presents the determinants of Infant Mortality in Northern Nigeria.

| Variable Name | Model I | Model II | Model III | Model IV |
|---|---|---|---|---|
| **Level of Maternal Education** | | | | |
| Primary | 1.027 | 0.990 | | 1.000 |
| Secondary/Higher | 1.000 | 1.000 | | 1.000 |
| None | 1.274 | 0.831 | | 1.111 |
| **Occupation of the Mother** | | | | |
| Agriculture | 1.000 | 1.000 | | 1.000 |
| Non-Agriculture | 1.031 | 1.035 | | 1.010 |
| Not Working | 0.751 | 0.677* | | 0.717* |
| **Wealth Index** | | | | |
| High | 1.000 | 1.000 | | 1.000 |
| Low | 1.191 | 1.222 | | 1.206 |
| Medium | 1.386 | 1.498* | | 0.838 |
| **Maternal Age** | | | | |
| 20-34 | | 1.000 | 1.000 | 1.000 |
| <20 | | 1.082 | 1.149 | 1.065 |
| 35+ | | 1.054 | 1.434 | 1.107 |
| **Source of Drinking Water** | | | | |
| Pipe/Tap | | 1.000 | | 1.000 |
| Borehole | | 0.974 | | 0.898 |
| Well | | 0.590* | | 0.488*** |
| Surface | | 0.704* | | 0.584*** |
| Other | | 0.738 | | 0.588 |
| **Presence of Toilet Facility** | | | | |
| Presence | | 1.000 | | 1.000 |
| Absence | | 1.180 | | 1.341 |
| **Preceding Birth Interval** | | | | |
| 2-3 & ≥ 24 months | | 1.000 | 1.000 | 1.000 |
| 2-3 & < 24 months | | 1.703* | 1.644* | 1.710* |
| 4+ & < 24 months | | 1.933** | 1.871*** | 1.840** |
| 4+ & ≥24 months | | 1.159 | 1.078 | 1.111 |
| First births | | 1.282 | 1.175 | 1.313 |

* $\rho < 0.05$; ** $\rho < 0.01$; *** $\rho < 0.001$.

From the results of analysis in Table 3, we see that, in all the four models, education was not a significant determinant of infant mortality in Northern Nigeria net all other factors. In fact in model I where only socio-economic and geographic factors were analyzed, no variable shows any statistical relationship to infant mortality. Turning to the occupation of the mother, we observed interesting results. Contrary to expectations where in urban areas working would be beneficial, in rural areas births to women who did not work were 0.25 less likely to experience infant mortality compared to those of women working in agriculture. The significant effect at 0.05 level persisted in Model IV net the effect of all factors. As regards to bio-demographic factors, the significance of birth order and preceding birth interval was observed. In all the models that the interactive effect was included, a persistent statistically significant positive influence on infant mortality compared to the reference category was observed. In model II, it was noted that infants in the 2- 3/<24 months and 4+/<24 months birth order/preceding birth interval categories were 70 percent and 93 percent more likely to die than those infants in the 2-3/≥24 months birth order/preceding birth interval category. Although the risk reduced somewhat in the subsequent models (III and IV), it was clear that the effect of birth order and preceding birth interval was important explanatory variable for infant mortality. Higher order births born in birth interval of less than or equal to 24 months were at higher risk of death compared to those born in the 2-3/ ≥24 months births order/preceding birth interval. In relation to environmental factors, and as in the case of the post-neonates, source of drinking water remained a significant explanatory factor even with infant mortality. In model II where socio-economic, bio-demographic and environmental factors were included, it was observed that the well and surface as sources of drinking water had 0.42

and 0.30 lower chances respectively, of infant deaths compared to households which accessed pipe/tap water both at 0.05 statistical significance level. In the full model (model IV), the significant effect of these two categories persisted at 0.001 significance level net the effect of all the other variables compared to the reference category of pipe/tap water.

## 4. CONCLUSION AND RECOMMENDATION

As observed, post-neonatal and infant mortality in Northern Nigeria were explained by occupation of the mother, household's wealth index, maternal age, birth order/preceding birth interval, source of drinking water and presence of a toilet facility in a household. Maternal level of education was not found to be significantly related to either post-neonatal or infant mortality in Northern Nigeria. There is a need to further understand this, more so with the existing abundant literature on the role of female education on child survival. A major surprise is the finding that households which use borehole/well/surface water were less likely to experience post-neonatal and infant deaths when compared to those households which use either pipe or tap water. Further investigation should be done to bring out a clear understanding of this reversal from what previous studies have reported.

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