Explaining Neonatal, Perinatal and Childhood Mortality Risks in Nigeria: Does Child's Risk Status at Birth Matter?

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Background

Nigeria, as some other lower income countries, has recorded considerable improvement in under-five survival in recent years with more children surviving to their fifth birthday now than was in 1990 (UN, 2018). The pace of progress, however, remains inadequate in meeting the country's target reduction in high rates of preventable deaths among new-borns and children below age five in tandem with global sustainable development goal 3 which aims at lowering the number of under-five deaths at country level to 25 per 1,000 live births by 2030. The latest report on global levels and trends of child mortality indicates that Nigeria accounts for thirteen percent of estimated deaths among children aged 0 and 59 months and still ranked among the top countries with lowest childhood survival chances for decades (UN, 2018).

Given its heavy burden of under-five deaths, Nigeria occupies an important position in the attainment of SDG globally and more importantly, in sub-Saharan Africa. Therefore, the imperative of continued search for pathways to increased survival chances for the country's children populations during infancy and childhood cannot be overemphasized. As studies have shown strong linkage between fertility behaviour and mortality in newborns and under five years' children (Ezeh et al. 2015; Ezeh et al. 2014; Stover & Ross, 2013; Kozuki et al. 2013a; Kozuki et al. 2013b), it can be argued that the high level of suboptimal fertility behaviour among Nigerian women exposes their babies to greater health and survival risks.

On the average, a Nigerian woman gives birth to over five children during her reproductive lifecycle. Also, at least 6 in 10 of childbirths (63.3%) occur in different risky contexts of extreme maternal ages at birth, higher birth order and/or preceding birth intervals that are either too close or too far apart (National Population Commission [NPopC] & ICF International, 2014). Generally, maternal age at birth, preceding birth interval and order of birth indicators characterizing childbirth have been used in disaggregating children into various risk groups as relate to their health and survival outcomes, leading to three broad child's risk status at birth classification: not high-risk, unavoidable risk, and avoidable high-risk status (Rutstein & Winter, 2014; Stover & Ross, 2013)

However, there is global dearth of country-specific evidence on the nexus between the risk context in which a child was born and the child's survival chances during the neonatal, postneonatal and childhood periods. A notable effort in this direction is a pooled analysis of DHS data from 45 countries including data from 2008 Nigeria DHS (Rutstein & Winter, 2014). This study, therefore, attempts to fill the identified knowledge gap and inform policy based on evidence from 2013 Nigeria Demographic and Health Survey dataset.

Theoretical Framework

This study is guided by Mosley and Chen (1984) framework for the study of child survival in developing countries. In explaining the framework, identified proximate and socioeconomic factors which the posited that jointly influence morbidity and mortality level in children population.

Data and Method

Data for this study was obtained from the 2013 Nigeria Demographic and Health Survey (NDHS) kids-recode dataset. The NDHS elicits information on background characteristics and demographic and health status of women aged 15-49 years selected via stratified multi-stage cluster design across 904 clusters (NPopC & ICF International, 2014). Data analysis was restricted to only last live births had by the women in the five years prior to the survey, resulting in a nationally representative sample of 31,260 study subjects.

The outcomes of interest are neonatal, postneonatal and child mortality risks operationalized as the new-born's risk of dying between age 0 to 28 days, 1 to 11 months and 12 to 59 months, respectively, and the specific point

in time during the interval death occurred. The information on survival status and duration of survival of a child was obtained from birth history data. Each outcome is dichotomously measured as 1- uncensored observation- indicating child death during the study duration, and 0- censored observation- signifying child survival beyond study duration.

The main analytical attribute is child's risk status at birth categorized and coded as:

1- Non-High-Risk (i.e. successive live births of order 2-3 and preceding birth interval 24-59 months to mothers 18-34 years),
2- Unavoidable Risk (i.e. first live births to mothers aged 18-34), and
3- Avoidable High-Risk (i.e. successive live births with combination/any of order 4 and above, preceding birth interval <24 months or >59 months, or mothers aged <18 or >34 characteristics).

Details about derivation and grouping of the main analytical predictor are accessible elsewhere (Rutstein & Winter, 2014; Stover & Ross, 2013).

Relationships between the outcome and main predictor were examined at descriptive level, based on Pearson's Chi-square test of association, as well as univariate and multivariate levels using Cox proportional hazards regression models. In all, one univariate and three multivariate hazards models were respectively employed in estimating the univariate hazard ratios (uHR) and multivariate hazard ratios (mHR) to evidence and compare size and significance of mortality risks children were exposed to across the risk dimension in neonatal, postneonatal or childhood phase considering roles of other selected covariates. The covariates were included based on their importance as have been established in previous studies (Adedini et al. 2015; Rutstein & Winter, 2014; Ezeh et al. 2015; Izugbara 2014; Ezeh et al. 2014; Kayode et al. 2012). Thus, the first model (**uHR**) predicted risks estimates by risk status dimension while the second model (**mHR^{1}**) controlled for child-specific biodemographic covariates (sex, birth size and birth multiplicity status). The third model (**mHR^{2}**) adjusted for mother- and household-specific correlates (marital status, educational level, employment status, wealth status, religion, household size as well as place and region of residence). Meanwhile, the last model (**mHR^{3}**) accounted for simultaneous contributions all the selected covariates to ascertain the net estimates of risks of death a Nigerian child would face belonging to any of the risk categories being considered.

Generally, the Cox proportional hazards regression model is represented as:

$$h_i(t_i;x_1) = h_0(t_i)\, e^{\beta_i X_i} = h_0(t) \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n) \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(a)}$$

where $h_0(t)$ symbolizes the unspecified baseline hazard function at time *t* for an individual whose characteristics, in form of a set of covariates vector $X_i = x=1, 2, \ldots, n$ assume value **0**; true regression coefficients vector $\beta_i = \beta_1 + \beta_2 + \ldots + \beta_n$ indicates relative hazards**.** Further, the hazard ratio indicated by parameter coefficient β_i is estimated by dividing both sides of equation **(a)** by the baseline hazard and taking the natural logarithm:

$$ln\,[h_i(t_i)/h_o(t_i)] = \beta_i X_i = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(b)}$$

where the quantity on the left-hand side of the equation represent the natural logarithm of hazard ratio and the estimated coefficient could take on values $est\beta \leq 0$or $est\beta \geq 1$ i.e. has range $0 \leq est\beta \geq 1$.

Inverse probability weight (v005/100000) was applied using Stata "svyset" command to correct for sampling disproportion, clustering and non-response in the data. Analyses were performed using Stata software for Windows version 14.0 (StataCorp, 2013).

Results/Key Findings

Table 1 presented the univariate (uHR) and multivariate hazard ratios (mHR) representing relationships between child's risk status at birth and risks of dying during the neonatal, postneonatal and childhood periods in Nigeria. The results indicated changing patterns and significant correlates of mortality risks in each of the periods under study. Generally, children born in avoidable high-risk contexts exhibited significantly consistent elevated risks of dying during the neonatal (mHR ranged from 1.53 to 1.33 | p<0.001), postneonatal (mHR ranged from 1.49 to 1.44 | p<0.001) and childhood (mHR ranged from 1.54 to 1.44 | p<0.001) periods compared to those born in reference non-high-risk context. Nevertheless, children in unavoidable risk group faced greater mortality risks in the neonatal phase than their counterparts in other risk groups (mHR 1.71 to 1.63 | p<0.001), while the risks of deaths weakened and became insignificant in the advanced postneonatal and childhood stages.

Results further showed significant mortality risk differential (p≤0.05) by sex and maternal marital status during the neonatal period, by place of residence during the neonatal and childhood stages, by maternal education and

employment status during the postneonatal and childhood stages and by birth size, birth type, family size and region of residence in all the three stages.

References

Adedini, S. A., Odimegwu, C., Imasiku, E. N., Ononokpono, D. N., & Ibisomi, L. (2014). Regional variations in infant and child mortality in Nigeria: a multilevel analysis. *Journal of Biosocial Science*, 1 - 23. doi:10.1017/S0021932013000734

Ezeh, O. K., Agho, K. E., Dibley, M. J., Hall, J., & Page, A. N. (2014). Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. *BMC Public Health, 14*(521). doi:10.1186/1471-2458-14-521

Ezeh, O. K., Agho, K. E., Dibley, M. J., Hall, J., & Page, A. N. (2015). Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria:a pooled cross-sectional analysis. *BMJ Open, e006779*, 5. doi:10.1136/bmjopen-2014-006779

Izugbara C. Whose child is dying? Household characteristics and under-5 mortality in Nigeria. South African J Child Heal. 2014;8(1):16–22. Available from: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1999-76712014000200005

Kayode, G. A., Adekanmbi, V. T., & Uthman, O. A. (2012). Risk factors and a predictive model for under-five mortality in Nigeria: evidence from Nigeria demographic and health survey. *BMC Pregnancy and Childbirth, 12*(10). doi:10.1186/1471-2393-12-10

Kozuki, Naoko; Lee, Anne C. C.; Silveira, Mariangela F.; Sania, Ayesha; Vogel, Joshua P.; Adair, Linda;... Child Health Epidemiology Reference Group (CHERG) Small-for-Gestational-Age-Preterm Birth Working Group. (2013a). The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Public Health, 13*(Suppl 3), S2. doi:10.1186/1471-2458-13-S3-S2

Kozuki, N., Lee, A. C. C., Silveira, M. F., Victora, C. G.; Adair, L, Humphrey, J.,... Child Health Epidemiology Reference Group Small-for-Gestational-Age-Preterm Birth Working Group. (2013b). The associations of birth intervals with small-forgestational- age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Public Health, 13*(Suppl 3), S3. doi:10.1186/1471-2458-13-S3-S3

Mosley, W. H., & Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. *Population and Development Review, 10*, 25-45. Retrieved from http://dx.doi.org/10.2307/2807954

National Population Commission & ICF International. (2014). *Nigeria Demographic and Health Survey 2013.* Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF International.

StataCorp LP. Stata Release 14. College Station, Texas: StataCorp LP; 2013. Available from: https://www.stata.com/stata13/

Stover, J., & Ross, J. (2013). Changes in the distribution of high-risk births associated with changes in contraceptive prevalence. *BMC Public Health, 13*(Suppl 3), S4. doi:10.1186/1471-2458-13-S3-S4

United Nations [UN]. (2018). *Levels and Trends in Child Mortality: Report 2018.* United Nations.

Table I. Univariate (uHR) and multivariate (mHR) hazards ratios of showing child's risks of dying during neonatal, postneonatal and childhood periods by child's risk status at birth for 30,822 live births had prior to 2013 Nigeria Demographic and Health Survey

	Neonatal Mortality Hazard Ratios				Postneonatal Mortality Hazard Ratios				Child Mortality Hazard Ratios			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
	uHR(CI)	mHR(CI)	mHR(CI)	mHR(CI)	uHR(CI)	mHR(CI)	mHR(CI)	mHR(CI)	uHR(CI)	mHR(CI)	mHR(CI)	mHR(CI)
Exposure Attribute												
Non-High-Risk [a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unavoidable Risk [b]	1.56(1.21-2.02)***	1.63(1.26-2.09)***	1.65(1.27-2.14)***	1.71(1.32-2.21)***	1.01(0.75-1.37)	1.03(0.76-1.38)	1.11(0.82-1.50)	1.12(0.82-1.51)	0.88(0.64-1.21)	0.88(0.64-1.22)	1.15(0.83-1.60)	1.15(0.83-1.59)
Avoidable High-Risk [c]	1.41(1.14-1.75)***	1.33(1.08-1.64)***	1.53(1.23-1.90)***	1.47(1.18-1.82)***	1.47(1.19-1.81)***	1.44(1.17-1.77)***	1.49(1.20-1.85)***	1.47(1.19-1.83)***	1.56(1.27-1.90)***	1.54(1.26-1.87)***	1.44(1.17-1.77)***	1.43(1.17-1.76)***
Child-Specific Characteristics												
Child's Sex												
Female		1.00		1.00		1.00		1.00		1.00		1.00
Male		1.32(1.15-1.50)***		1.32(1.15-1.50)***		1.08(0.91-1.28)		1.08(0.92-1.28)		1.07(0.91-1.26)		1.06(0.90-1.25)
Birth Size												
Big		1.00		1.00		1.00		1.00		1.00		1.00
Small		2.09(1.78-2.46)***		2.01(1.70-2.38)***		1.67(1.39-2.01)***		1.54(1.27-1.86)***		1.76(1.47-2.12)***		1.49(1.24-1.78)***
Birth Type												
Single		1.00		1.00		1.00		1.00		1.00		1.00
Multiple		4.23(3.34-5.34)***		4.68(3.70-5.93)***		2.1(1.48-2.96)***		2.40(1.70-3.40)***		1.36(0.92-2.01)		1.65(1.11-2.45)*
Maternal/Household-Specific Characteristics												
Marital Status												
Not in Union			1.00	1.00			1.00	1.00			1.00	1.00
In Union			0.77(0.57-1.04)	0.74(0.55-1.00)*			0.73(0.52-1.04)	0.72(0.51-1.02)			0.87(0.58-1.30)	0.86(0.58-1.28)
Education Level												
None			1.00	1.00			1.00	1.00			1.00	1.00
Primary			1.13(0.92-1.40)	1.15(0.94-1.41)			0.79(0.63-0.99)*	0.80(0.63-1.01)			0.98(0.73-1.32)	0.99(0.74-1.34)
Secondary/Higher			0.78(0.57-1.06)	0.81(0.60-1.10)			0.66(0.51-0.85)***	0.67(0.52-0.87)***			0.59(0.40-0.88)***	0.60(0.41-0.89)*
Employment Status												
Unemployed			1.00	1.00			1.00	1.00			1.00	1.00
Employed			0.97(0.82-1.13)	0.96(0.82-1.12)			1.08(0.90-1.29)	1.07(0.89-1.29)			1.26(1.04-1.53)*	1.25(1.03-1.53)*
Wealth Status												
Poor			1.00	1.00			1.00	1.00			1.00	1.00
Not Poor			0.95(0.78-1.15)	0.97(0.81-1.17)			0.73(0.58-0.92)***	0.74(0.58-0.93)*			0.61(0.47-0.79)***	0.61(0.47-0.80)***
Religion												
Muslim			1.00	1.00			1.00	1.00			1.00	1.00
Christian			1.07(0.83-1.37)	1.09(0.85-1.41)			1.19(0.91-1.55)	1.20(0.91-1.56)			0.64(0.44-0.95)*	0.65(0.44-0.95)*
Other			0.94(0.55-1.60)	0.94(0.56-1.57)			1.05(0.61-1.81)	1.06(0.62-1.81)			0.86(0.47-1.56)	0.86(0.47-1.57)
Family Size												
Small			1.00	1.00			1.00	1.00			1.00	1.00
Large			0.59(0.50-0.68)***	0.56(0.48-0.65)***			0.62(0.51-0.75)***	0.60(0.50-0.73)***			0.71(0.60-0.83)***	0.70(0.60-0.83)***
Place of Residence												
Rural			1.00	1.00			1.00	1.00			1.00	1.00
Urban			0.78(0.64-0.96)*	0.77(0.64-0.94)***			0.88(0.70-1.12)	0.88(0.69-1.11)			0.66(0.51-0.85)***	0.66(0.51-0.85)***
Region of Residence												
North West			1.00	1.00			1.00	1.00			1.00	1.00
North East			0.90(0.73-1.12)	0.88(0.71-1.10)			0.86(0.69-1.08)	0.84(0.67-1.06)			0.99(0.81-1.21)	0.97(0.80-1.19)
North Central			0.81(0.62-1.06)	0.80(0.62-1.04)			0.78(0.56-1.10)	0.79(0.56-1.12)			0.65(0.47-0.92)*	0.67(0.48-0.94)*
South East			0.98(0.69-1.39)	0.90(0.64-1.27)			1.37(0.95-1.98)	1.33(0.92-1.92)			1.41(0.85-2.34)	1.38(0.83-2.29)
South South			0.70(0.48-1.03)	0.66(0.46-0.94)*			0.74(0.49-1.13)	0.73(0.48-1.10)			1.05(0.66-1.66)	1.03(0.65-1.64)
South West			0.97(0.71-1.32)	0.91(0.68-1.21)			0.60(0.40-0.91)*	0.60(0.40-0.90)*			0.72(0.43-1.20)	0.72(0.43-1.20)

* p<.05, ** p<0.01, *** p<0.01; [a] successive births of order 2-3 and preceding birth interval 24-59 months to mothers 18-34 years ; [b] first births to mothers aged 18-34; [c] successive live births with combination/any of order 4 and above, preceding birth interval <24 months or >59 months, or mothers aged <18 or >34 characteristics