ORIGINAL RESEARCH ARTICLE

Child's Risk Attributes at Birth and Infant Mortality Disparities in Nigeria

DOI: 10.29063/ajrh2019/v23i3.11

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Abstract

Births in avoidable high-risk contexts defined by the interplay of sub-optimal childbearing age, short spacing, and first and high birth order incur elevated risks of childhood death. However, the extent of disparities in risks of dying in infancy vis-à-vis the continuum of non-high-risk and (un)avoidable high-risk attributes at birth as determined by mother's age at childbirth, child spacing, and birth order characteristics is yet to be adequately explored in Nigeria as elsewhere. To fill this gap, chi-square association test and Cox's proportional hazards regression were used to analyze data of 31,260 nationally representative children aged 0-59 months drawn from 2013 Nigeria Demographic and Health Survey. Disparities in infant mortality risks were mainly examined across the spectrum of birth-related risk attributes at birth broadly categorized as no extra high-risk, unavoidable first-order risk and combined avoidable high-risk. The risks of dying in infancy differed significantly by risk attributes to the extent dictated by other confounders. Also, infant mortality risks varied significantly by all moderating factors excluding religion, water source, toilet type and place of delivery. Interventions targeted at reducing avoidable high-risk fertility rate and strengthening health system to provide life-saving care to most-at-risk children would engender rapid improvement in infant survival. *(Afr J Reprod Health 2019; 23[3]:120-133).*

Keywords: Infant Mortality, High-Risk Birth, Fertility Behaviour, Disparities, Nigeria

Résumé

Les naissances dans des contextes à risque élevé évitables, définies par l'interaction d'un âge de procréation sous-optimal, d'un espacement réduit, et du premier rang de naissance élevé, entraînaient des risques élevés de mortalité infantile. Toutefois, l'ampleur des disparités en matière de risque de décès dans la petite enfance par rapport au continuum d'attributs à haut risque non haut risque et (in) évitables haut risques à la naissance, déterminée par l'âge de la mère à la naissance, l'espacement des naissances et le rang de naissance les caractéristiques n'a pas encore été explorée de manière adéquate au Nigeria comme ailleurs. Pour combler cette lacune, le test d'association du khi-deux et la régression des hasards proportionnels de Cox ont été utilisés pour analyser les données de 31 260 enfants représentatifs au niveau national, âgés de 0 à 59 mois tirés de l'enquête démographique et de santé réalisée en 2013 au Nigéria. Les disparités dans les risques de mortalité infantile ont été principalement examinées à travers le spectre d'attributs de risque liés à la naissance, généralement classées dans la catégorie comme pas de haut risque supplémentaire, à très haut risque, risque inévitable de premier ordre et le haut évitable combiné. Les risques de mourir dans la petite enfance différaient considérablement par les attributs de risque dans la mesure dictée par d'autres facteurs de confusion. En outre, les risques de mortalité infantile variaient de manière significative en fonction de tous les facteurs modérateurs, à l'exclusion de la religion, de la source d'eau, du type de toilette et du lieu de livraison. Les interventions visant à réduire le taux de fécondité évitable à haut risque et à renforcer le système de santé afin de fournir des soins vitaux aux enfants les plus exposés, engendreraient une amélioration rapide de la survie des nourrissons. *(Afr J Reprod Health 2019; 23[3]: 120-133).*

Mots-clés: Mortalité infantile, naissances à haut risque, comportement de la fécondité, disparités, Nigéria

Introduction

High rate of mortality in infancy constitutes major demographic and public health concern in Nigeria. Successive administrations in Nigeria have made concerted efforts to reverse this trend through myriads of policies and programmes. The interventions were tied to various laudable initiatives like the Millennium Development Goals (MDGs) programmes (which transitioned to Sustainable Development Goals), National Policy on Population for Sustainable Development, National Child Health Policy, the Integrated Maternal, New-born and Child Health intervention, the Midwives Service Scheme and the Maternal and Child Health component of the Subsidy Reinvestment and Empowerment Programme [1]. Nevertheless, the gains made were inadequate in meeting the country's infant and child mortality reduction targets[1].

Nigeria contributes approximately 11 and 24 percent of estimated infant mortality burden globally and in sub-Saharan Africa respectively[2]. Besides, huge proportion of children dying before age 5 increasingly concentrates in the period of infancy. This progressive increase in the proportion of deaths during eleven months after birth indicates growing vulnerability of dying during infancy than any other time prior to age five [1,2]. Accordingly, infant deaths account for approximately three-quarters of estimated under-five deaths in Nigeria [2]. Furthermore, recent statistics suggest a sharp inter-survey drop in the pace of reduction in infant mortality rate from 25 percent between 2003 and 2008 to 8 percent between 2008 and 2013[1].

Arguably, Nigeria's high infant mortality profile is substantially rooted in women's sub-optimal fertility behaviours aside other factors. Data from Nigeria Demographic and Health Survey (NDHS) reports[1,3] attest to this assertion. According to the reports, an average Nigerian woman tends to give birth to approximately six children over her reproductive years. In relation to this high fertility phenomenon, close to two-thirds of the children are born in practically preventable risk contexts characterized by early/late childbearing, close interval between births and extreme birth order, with slight decrease in proportion from approximately 65 to 63 percent between 2003 and 2013.

Evidently, high fertility coexists with high childhood mortality[2]. Also, studies have found increased risks of deaths among infants born to teenage or old mothers, in quick succession and of first or high birth order[4-13]. In general, maternal age at birth, preceding birth interval and order of birth characteristics have been used in classifying child's birth-related risks of death into three broad hypothetical categories, namely, not in high-risk, unavoidable first birth risk and avoidable high-risk which encompasses a range of single and combined avoidable high-risks dimensions[1,5,14].

However, there is paucity of evidence on the pattern and extent of infant mortality disparities across the continuum of the hypothetical risk categories. Summary estimates of under-five mortality risks by these vulnerability indicators as routinely presented in the NDHS reports have two major limitations that form the bases for this investigation. Firstly, they are not generalizable to all critical age segments under five, especially the first year of birth in which the greater proportion of under-five deaths occurs. Secondly, the estimates are not adjusted for demographic, socioeconomic and healthcare services covariates that have been found to influence child health and survival outcomes. To address this gap, this study draws on 2013 NDHS kids-recode data to examine the risks of dying in infancy by child's risk attributes at birth and constituent domains taking into cognizance the contributions of other correlates.

Methods

Data source and study sample

This investigation employed a nationally representative, cross-sectional, kids-recode dataset drawn from the 2013 NDHS data. The NDHS was implemented between February and June 2013 by the Nigeria Population Commission to elicit information on demographic and health indicators at the national and state levels. The study protocol and survey instruments for 2013 NDHS were approved by the National Health Research Ethics Committee of the Federal Ministry of Health, Nigeria. Informed consent was obtained from all the study participants including parents and guardians[1].

The study sample was restricted to total number of live births reportedly had by successfully interviewed women in the five years prior to the survey. Based on this criterion, this study included a weighted total of 31,260 live births delivered for 0-59 months preceding the survey. The data were released for use in this study by ICF International.

Definition and classification of variables

The outcome measure is risk of dying in infancy (RDI) measured as the duration of survival within the first 11 months of birth. The RDI was mainly predicted by child's risk attribute at birth; which, in line with Demographic and Health Surveys (DHS) definitions, was determined by interacting maternal age at birth ('*<18/younger*', '*18-34/middle*' and '*35+/older*'), birth order (classified as *'1/first*', '*2-3/middle*' and '*4+/higher'*) and preceding birth interval (grouped as '*<24/short'* and '*24+/long*') attributes[1,14].

The derived child's risk attributes were classified into three main comparative groups as follows:

1. *Non-high risk* (i.e. risk trait of successive live births of order 2-3 and preceding birth interval 24-59 months to mothers 18-34 years);
2. *Unavoidable first-order risk* (i.e. risk trait of first live births to mothers aged 18-34); and
3. *Avoidable high-risk* (i.e. risk trait of successive live births with any or a combination of birth order >3 [too high order], preceding birth interval <24 months [too short interval], or mothers age at birth <18 [too young mother] or >34 [too old mother] characteristics). Consequently, the avoidable high-risk attribute was further disaggregated as *avoidable single-factor high-risk* (i.e. risk trait of successive live birth born with only one indicator of avoidable high-risk attributes) *avoidable double-factor high-risk* (i.e. risk trait of successive live birth born with two elements of avoidable high-risk attributes), and *avoidable triple-factor high-risk* (i.e. risk trait of successive live birth born with three indicators of avoidable high-risk attributes).

Moreover, seventeen supplementary covariates included based on evidence from extant literature were grouped as:

a. Child bio-demographic characteristics: child's sex (female vs. male), birth type (single vs. multiple), birth size (small vs. average, large)
b. Maternal/household's demographic and socioeconomic characteristics: marital status (not in union vs. in union), education (none vs. primary, secondary/higher), religion (Christianity vs. Islam; Others), region of residence (South East vs. North Central, North East, North West, South-South, South West), place of residence (urban vs. rural), household size (small vs. large, very large), wealth status (poor vs. rich), water sources (unimproved, improved), and toilet type (unimproved, improved)
c. Maternal healthcare access/use characteristics: distance to facility (big challenge vs. not big challenge), prenatal care visit (none vs. one/more), prenatal care provider (unskilled vs. skilled), tetanus immunization (not received vs. received) and place of delivery (elsewhere vs. facility).

For instance, research have shown that child's sex[6–10,15–17], birth multiplicity status[6,10,12,18] and birth size[8,17,19] play significant roles in child survival. Similarly, several studies have established that risks of childhood death vary substantially by mother's marital status[7], education[6,11,15,20], religious affiliation[7], place and region of residence[9,11], healthcare access and utilization[9,12,19,21] and wealth status[7–9,15,18], as well as household size[12] and sanitation and hygiene[7,9,20].

Statistical analyses

Pearson's Chi-square test was used to explore variations in infant deaths distribution by risk status dimensions and categories in selected covariates. In addition, based on Mosley-Chen analytical framework[22], disparities in infant mortality risks were investigated by comparing hazard ratios from Cox's proportional hazards regression models. Detailed explanation of proportional hazards regression technique as well as justification for its use in childhood mortality research is well documented[5,8,9].

In line with the study objective, hazard ratios were examined across one bivariate and five multivariate models. These models were estimated on the assumption that the pattern of resulting mortality risks by risk dimensions under focus will vary considerably under the influence of different set of covariates. Consequently, the bivariate model examined relationship between risk attributes on infant deaths, while the first multivariate model adjusted for child-specific bio-demographic predictors. Whereas the second and third multivariate models modified for mother-specific demographic/socioeconomic and healthcare access/use characteristics, respectively, the fourth model accounted for joint contributions of all child- and mother-specific covariates. Meanwhile, the fifth multivariate model included only a set of correlates with predictive value of $p<0.05$ in a backward stepwise elimination regression. Data were analyzed with STATA version 14.0[23] and statistical significance evaluated at $p \leq .05$.

Results

Population distribution and survival status

Table 1 presents the distributions of the study population and infant deaths by child's risk attributes and selected covariates. Overall, a total of 31,260 live births were delivered 0-59 months prior to the survey comprising 29,273 (93.6%) and 1,987 (6.4%) children who survived and died in infancy, respectively. In aggregate, 22.6% of the study population were born with non-high-risk characteristics compared with 63.5% born with avoidable high-risk attributes, comprising 34.4, 26.9 and 2.2% in single-, double- and triple-factor high-risk subgroups. Moreover, relative to their counterparts in the study were 49.5% female, 96.6% singleton and 16.8% small birth-size children. Also, children whose mothers were not in union, uneducated, Christians, poor, declared small household size, rural resident, located in south east region, had no prenatal care and received no tetanus injection constituted 4.2, 49.1, 36.7, 46.5, 40.5, 65.0, 8.9, 59.2 and 68.7% of total in each of the respective parameters.

Besides, the pattern of infant deaths varied significantly by risk attributes at birth. Overall, least proportion of infant deaths occurred among children in non-high-risk group (4.8%) relative to those in unavoidable first-order risk (6.3%) and avoidable high-risk (6.9%) groups (χ^2=36.68, $p<.001$). Similarly, results of disaggregated avoidable high-risk dimension showed that infancy deaths were least prevalent among babies born with avoidable single-factor high-risk characteristics (5.5%) proportionate to their equals born with avoidable double- (8.3%) and triple-factor (13.1%) high-risk attributes (χ^2=146.37, $p<.001$).

In addition, occurrence of deaths in infancy varied significantly by all correlates except religion and perception about distance to health facility (Table 1). Consequently, the proportion of children who died before age 1 differed by child's sex (χ^2=16.31, $p<.001$), birth type (χ^2=379.81, $p<.001$), birth size (χ^2=241.56, $p<.001$). Also, the results showed, for example, significant association between mother education (χ^2=52.03, $p<.001$), wealth status (χ^2=66.13, $p<.001$), household size (χ^2=90.74, $p<.001$), place (χ^2=41.52, $p<.001$) and region (χ^2=40.57, $p<.001$)

Table 1: Population distribution and survival status, 31,260 children born 0-59 months prior to 2013 NDHS

Parameters	Population [a] 31260 (%)	Survival Status [b] Alive (93.6)	Dead (6.4)	Chi-Square Estimate
Risk Attribute				
Non-High-Risk	7079 (22.6)	95.2	4.8	38.68***
Unavoidable First-Order Risk	4317 (13.8)	93.7	6.3	
Avoidable High-Risk	19864 (63.5)	93.1	6.9	
First-Level Disaggregation				
Risk Attribute				
Non-High-Risk	7079 (22.6)	95.2	4.8	146.37***
Unavoidable First-Order Risk	4317 (13.8)	93.7	6.3	
Avoidable High-Risk Dimensions:				
Avoidable Single-Factor High-Risk	10749 (34.4)	94.5	5.5	
Avoidable Double-Factor High-Risk	8421 (26.9)	91.7	8.3	
Avoidable Triple-Factor High-Risk	694 (2.2)	86.9	13.1	
Second-Level Disaggregation				
Risk Attribute				
Non-High-Risk	7079 (22.6)	95.2	4.8	230.15***
Unavoidable First-Order Risk	4317 (13.8)	93.7	6.3	
Avoidable Single-Factor High-Risk Dimensions:				
Too Young Mother	298 (1.0)	90.1	9.9	
Too Old Mother	302 (1.0)	95.8	4.2	
Too Short Interval	2211 (7.1)	92.9	7.1	
Too High Order	7939 (25.4)	95.1	4.9	
Avoidable Double-Factor High-Risk Dimensions:				
Too Young Mother + Too Short Interval	197 (0.6)	88.2	11.8	
Too Young Mother + First Order	1727 (5.5)	90.9	9.1	
Too Old Mother + Too Short Interval	43 (0.1)	100.0	0.0	
Too Old Mother + First Order	52 (0.2)	94.4	5.6	
Old Mother + Too High Order	3707 (11.9)	93.8	6.2	
Too Short Interval + Too High Order	2694 (8.6)	89.6	10.4	
Avoidable Triple-Factor High-Risk Dimensions:				
Too Young Mother + Too Short Interval + Too High Order	4 (0.0)	100.0	0.0	
Too Old Mother + Too Short Interval + Too High Order	690 (2.2)	86.8	13.2	
Child's Sex				
Female	15482 (49.5)	94.2	5.8	16.31***
Male	15778 (50.5)	93.1	6.9	
Birth Type				
Single	30190 (96.6)	94.2	5.8	379.81***
Multiple	1070 (3.4)	79.3	20.7	
Birth Size				
Small	5244 (16.8)	88.9	11.1	241.56***
Average	12581(40.2)	94.3	5.7	
Large	13435 (43.0)	94.9	5.1	
Marital Status				
Not in Union	1328 (4.2)	92.1	7.9	5.33*
In Union	29932 (95.8)	93.7	6.3	
Mother's Education				
None	15355 (49.1)	92.8	7.2	52.03***
Primary	6013 (19.2)	93.3	6.7	
Secondary/Higher	9892 (31.6)	95.1	4.9	
Religion				

Christianity	11475 (36.7)	94.1	5.9	5.17
Islam	19300 (61.7)	93.4	6.6	
Others	485 (1.6)	93.5	6.5	
Wealth Status				
Poor	14543 (46.5)	92.4	7.6	66..13***
Rich	16717 (53.5)	94.7	5.3	
Household Size				
Small	12658 (40.5)	92.1	7.9	90.74***
Large	14227 (45.5)	94.6	5.4	
Very large	4375 (14.0)	95.1	4.9	
Water Source				
Unimproved	16226 (51.9)	93.2	6.8	9.59*
Improved	15034 (48.1)	94.1	5.9	
Toilet Type				
Unimproved	18897 (60.5)	93.3	6.7	11.59**
Improved	12363 (39.5)	94.2	5.8	
Place of Residence				
Rural	20331 (65.0)	93.0	7.0	41.52***
Urban	10929 (35.0)	94.9	5.1	
Region of Residence				
South East	2788 (8.9)	92.9	7.1	40.57***
North Central	4271 (13.7)	94.3	5.7	
North East	5465 (17.5)	93.6	6.4	
North West	11542 (36.9)	92.8	7.2	
South South	2902 (9.3)	95.0	5.0	
South West	4292 (13.7)	94.9	5.1	
Distance to Facility				
A Barrier	10045 (32.1)	93.6	6.4	0.08
Not a Barrier	21215 (67.9)	93.7	6.3	
Prenatal Care Visit				
None	18499 (59.2)	92.0	8.0	206.59***
One/More	12761 (40.8)	96.0	4.0	
Prenatal Care Provider				
Unskilled	19029 (60.9)	92.1	7.9	195.19***
Skilled	12231 (39.1)	96.1	3.9	
Tetanus Vaccination				
Not Received	21488 (68.7)	92.5	7.5	156.75***
Received	9772 (31.3)	96.2	3.8	
Place of Delivery				
Elsewhere	20046 (64.1)	93.1	6.9	25.84***
Facility	11214 (35.9)	94.6	5.4	

Notes: [a], column dist number and percentage; [b], row percent distribution; *p<.05, **p<.01, ***p<.001

of residence, prenatal care visit (χ^2=206.59, p<.001), prenatal care provider (χ^2=195.19, p<.001), tetanus vaccination (χ^2=156.75, p<.001) and incidence of infant death.

Risk status at birth and infant mortality risks nexus

Findings from Figures 1 and 2 and Tables 2a and 2b illustrate the patterns and relative degrees of infant mortality risks per risk attributes that characterized the births of the study population. Overall, the results showed significant disparities in exposure to mortality risks across risk categories. The Kaplan-Meier's plots (Figures 1 and 2) revealed that chances of dying and magnitude of infant mortality disparities by various risk dimensions were more pronounced during the first five months after birth as the baseline hazards decline rapidly and stabilize

Table 2a: Proportional hazards regression estimates of risks of dying in infancy by risk attributes of 31,260 children born 0-59 months prior to 2013 NDHS

Parameters	Model 1 bHR	95% C.I.	Model 2 mHR[1]	95% C.I.	Model 3 mHR[2]	95% C.I.	Model 4 mHR[3]	95% C.I.	Model 5 mHR[4]	95% C.I.	Model 6 mHR[5]	95% C.I.
Risk Attribute (Non-High-Risk, ref.)	1.00		1.00		1.00		1.00		1.00		1.00	
Unavoidable First-Order Risk	1.32**	(1.10,1.60)	1.36**	(1.13,1.64)	1.33**	(1.10,1.61)	1.34**	(1.11,1.63)	1.31**	(1.08,1.59)	1.32**	(1.08,1.60)
Avoidable High-Risk	1.45***	(1.26,1.67)	1.39***	(1.20,1.59)	1.62***	(1.41,1.87)	1.41***	(1.22,1.63)	1.58***	(1.37,1.82)	1.60***	(1.39,1.84)
First-Level Disaggregation												
Risk Attribute (Non-High-Risk, ref.)	1.00		1.00		1.00		1.00		1.00		1.00	
Unavoidable First-Order Risk	1.32**	(1.10,1.60)	1.36**	(1.13,1.64)	1.33**	(1.10,1.61)	1.34**	(1.11,1.63)	1.31**	(1.08,1.59)	1.32**	(1.08,1.60)
Avoidable High-Risk Dimensions:												
Avoidable Single-Factor High-Risk	1.14	(0.96,1.34)	1.09	(0.92,1.28)	1.31**	(1.11,1.55)	1.11	(0.95,1.31)	1.26**	(1.07,1.49)	1.28**	(1.08,1.50)
Avoidable Double-Factor High-Risk	1.74***	(1.50,2.03)	1.67***	(1.44,1.94)	1.92***	(1.65,2.24)	1.69***	(1.46,1.96)	1.89***	(1.63,2.19)	1.90***	(1.64,2.21)
Avoidable Triple-Factor High-Risk	2.81***	(2.13,3.71)	2.59***	(1.93,3.47)	3.40***	(2.59,4.48)	2.70***	(2.06,3.55)	3.20***	(2.41,4.25)	3.21***	(2.40,4.29)
Second-Level Disaggregation [a]												
Risk Attribute (Non-High-Risk, ref.)	1.00		1.00		1.00		1.00		1.00		1.00	
Unavoidable First-Order Risk	1.32**	(1.10,1.60)	1.36**	(1.13,1.64)	1.33**	(1.10,1.61)	1.34**	(1.11,1.63)	1.31**	(1.08,1.59)	1.32**	(1.08,1.60)
Avoidable Single-Factor High-Risk Dimensions:												
Too Young Mother	2.09**	(1.30,3.36)	1.75*	(1.08,2.85)	1.74*	(1.08,2.79)	1.80*	(1.11,2.90)	1.39	(0.85,2.25)	1.39	(0.85,2.25)
Too Old Mother	0.88	(0.50,1.55)	0.84	(0.48,1.48)	1.00	(0.57,1.76)	1.07	(0.61,1.87)	1.04	(0.59,1.83)	1.03	(0.59,1.81)
Too Short Interval	1.49***	(1.18,1.89)	1.46**	(1.16,1.85)	1.49**	(1.17,1.88)	1.43**	(1.13,1.80)	1.40**	(1.11,1.76)	1.44**	(1.14,1.81)
Too High Order	1.02	(0.85,1.22)	0.96	(0.81,1.15)	1.24*	(1.03,1.50)	1.00	(0.83,1.20)	1.24*	(1.03,1.48)	1.24*	(1.04,1.49)
Avoidable Double-Factor High-Risk Dimensions:												
Too Young Mother + Too Short Interval	2.53***	(1.56,4.08)	2.67***	(1.65,4.33)	2.18**	(1.35,3.53)	2.20**	(1.36,3.56)	2.22**	(1.38,3.57)	2.21**	(1.37,3.57)
Too Young Mother + First Order	1.93***	(1.56,2.40)	1.91***	(1.54,2.37)	1.61***	(1.29,2.00)	1.74***	(1.40,2.16)	1.53***	(1.23,1.89)	1.52***	(1.23,1.89)
Too Old Mother + First Order	1.17	(0.35,3.87)	1.14	(0.34,3.85)	1.08	(0.32,3.61)	1.35	(0.41,4.52)	1.13	(0.33,3.86)	1.24	(0.36,4.24)
Too Old Mother + Too High Order	1.31**	(1.07,1.59)	1.24*	(1.02,1.50)	1.64***	(1.34,2.01)	1.38**	(1.13,1.68)	1.71***	(1.41,2.08)	1.72***	(1.42,2.10)
Too Short Interval + Too High Order	2.21***	(1.87,2.61)	2.11***	(1.79,2.50)	2.64***	(2.21,3.16)	2.03***	(1.72,2.40)	2.51***	(2.11,2.99)	2.55***	(2.14,3.04)
Avoidable Triple-Factor High-Risk Dimension:												
Too Old Mother + Too Short Interval + Too High Order	2.83***	(2.14,3.73)	2.60***	(1.94,3.49)	3.46***	(2.63,4.56)	2.72***	(2.07,3.57)	3.28***	(2.47,4.36)	3.30***	(2.47,4.41)

Notes: bHR, bivariate hazard ratios; mHR, multivariate hazard ratios; C.I., confidence interval; *p<.05, **p<.01, ***p<.001; ref., reference category; mHR[1], adjusted for child-specific bio-demographic predictors- see Table 2b; mHR[2], modified for mother-specific demographic/socioeconomic characteristics- see Table 2b; mHR[3], controlled for mother-specific healthcare access/use characteristics- see Table 2b; mHR[4], full model, adjusted for all parameters- see Table 2b; Model 6, controlled for a set of correlates with predictive value within 5% significance level threshold in a backward stepwise elimination regression- see Table 2b; [a], dimensions with no statistical convergence due too few samples excluded

Table 2b: Proportional hazards regression estimates of risks of dying in infancy by risk attributes of 31,260 children born 0-59 months prior to 2013 NDHS

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
Parameters [a]	bHR	95% C.I.	mHR[1]	95% C.I.	mHR[2]	95% C.I.	mHR[3]	95% C.I.	mHR[4]	95% C.I.	mHR[5]	95% C.I.
Risk Attribute (Non-High-Risk, ref.)	1.00		1.00		1.00		1.00		1.00		1.00	
Unavoidable First-Order Risk	1.32**	(1.10,1.60)	1.36**	(1.13,1.64)	1.33**	(1.10,1.61)	1.34**	(1.11,1.63)	1.31**	(1.08,1.59)	1.32**	(1.08,1.60)
Avoidable High-Risk	1.45***	(1.26,1.67)	1.39***	(1.20,1.59)	1.62***	(1.41,1.87)	1.41***	(1.22,1.63)	1.58***	(1.37,1.82)	1.60***	(1.39,1.84)
Child's Sex (Female, ref.)			1.00						1.00		1.00	
Male			1.21***	(1.09,1.34)					1.21***	(1.09,1.34)	1.20***	(1.09,1.34)
Birth Type (Single, ref.)			1.00						1.00		1.00	
Multiple			3.51***	(2.89,4.25)					3.50***	(2.89,4.23)	3.51***	(2.90,4.25)
Birth Size (Small, ref.)			1.00						1.00		1.00	
Average			0.56***	(0.48,0.64)					0.60***	(0.52,0.69)	0.60***	(0.52,0.70)
Large			0.49***	(0.43,0.56)					0.54***	(0.48,0.62)	0.54***	(0.47,0.61)
Marital Status (Not in Union, ref.)					1.00				1.00		1.00	
In Union					0.76*	(0.60,0.96)			0.70**	(0.56,0.88)	0.70**	(0.56,0.87)
Mother's Education (None, ref.)					1.00				1.00		1.00	
Primary					0.99	(0.85,1.15)			1.06	(0.90,1.23)	1.09	(0.94,1.26)
Secondary/Higher					0.74**	(0.59,0.93)			0.84	(0.67,1.06)	0.90	(0.75,1.09)
Wealth Status (Poor, ref.)					1.00				1.00		1.00	
Rich					0.86*	(0.74,1.00)			0.90	(0.77,1.05)	0.89	(0.77,1.03)
Household Size (Small, ref.)					1.00				1.00		1.00	
Large					0.54***	(0.47,0.61)			0.50***	(0.45,0.57)	0.51***	(0.45,0.58)
Very large					0.45***	(0.37,0.53)			0.41***	(0.34,0.50)	0.41***	(0.34,0.50)
Place of Residence (Rural, ref.)					1.00				1.00		1.00	
Urban					0.84*	(0.71,0.99)			0.84*	(0.70,0.99)	0.90	(0.77,1.05)
Region of Residence (South East, ref.)					1.00				1.00			
North Central					0.74*	(0.57,0.95)			0.78	(0.60,1.02)		
North East					0.79	(0.59,1.04)			0.79	(0.59,1.06)		
North West					0.90	(0.69,1.18)			0.89	(0.67,1.18)		
South South					0.63***	(0.48,0.83)			0.62***	(0.48,0.81)		
South West					0.74*	(0.55,0.99)			0.76	(0.57,1.01)		

Distance to Facility (A Barrier, ref.)	1.00		1.00			
Not a Barrier	1.14*	(1.00,1.29)	1.21**	(1.07,1.36)		
Prenatal Care Visit (None, ref.)	1.00		1.00			
One/More	0.69**	(0.54,0.88)	0.71**	(0.56,0.90)		
Prenatal Care Provider (Unskilled, ref.)	1.00		1.00		1.00	
Skilled	0.83	(0.63,1.08)	0.87	(0.66,1.14)	0.66***	(0.56,0.79)
Tetanus Vaccination (Not Received, ref.)	1.00		1.00		1.00	
Received	0.79*	(0.65,0.97)	0.82	(0.67,1.01)	0.78*	(0.65,0.94)

Notes: [a], only covariates with significant hazard ratios presented in the table; *p<.05, **p<.01, ***p<.001; see Table 2a for additional notes

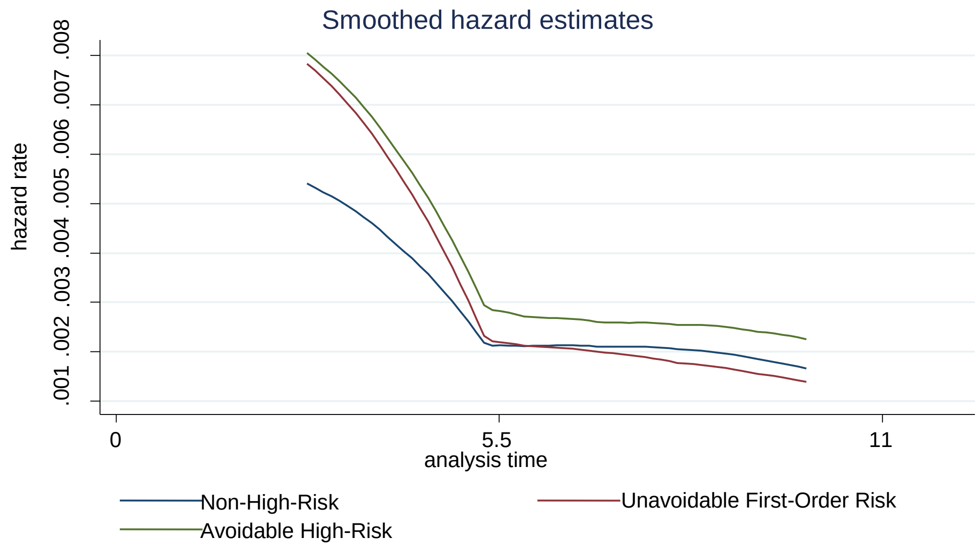

Figure 1: Kaplan-Meier plot of hazards of dying in infancy by three-dimension risk attributes

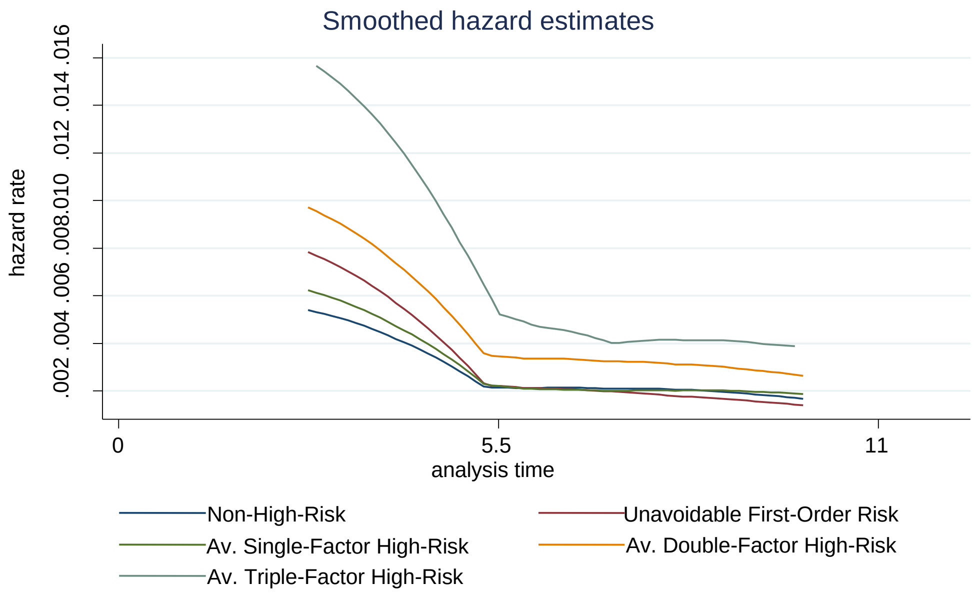

Figure 2: Kaplan-Meier plot of hazards of dying in infancy by five-dimension risk attributes

afterwards. The plots further depicted that, compared with others, avoidable high-risk traits exposed newborns to far greater hazards of deaths throughout the infancy period, mainly accentuated by double and triple avoidable high-risk attributes.

In consonance with the illustrated results, the hazard ratios per risk attribute presented in Table 2a established that relative to children in non-high-risk group, risks of dying in infancy were substantially elevated for those in unavoidable first-order risk group by 36-32% ($p<.01$) and for those in avoidable high-risk group by 62-39% ($p<.001$). Further results at first level of disaggregation affirmed consistent dose-response trends in risks of death by avoidable high-risk constituent groups with babies born in one- and three-factor high-risk contexts being exposed, respectively, to the least ($p\geq.01$) and the most ($p<.001$) accentuated hazards of dying in infancy compared to those born in non-high-risk context. Meanwhile, supplementary results at second disaggregation level revealed considerably mixed infant mortality risk differentials across the specific one-, two- and three-factor high-risk dimensions as influenced by various set of covariates adjusted for.

Table 2b showed results for only the correlates with between-group mortality risk variations at $p\leq.05$ level of significance. The results revealed that males and non-singletons were at least 20% and 250% times more likely to die in infancy than females and singletons ($p<.001$). Also, the results showed significant inverse relationship between risks of infant death and size at birth (small, 1.00 vs. average, 0.60-0.56 vs. large 0.54-0.49; $p<.001$) and household size (small, 1.00 vs. large 0.54-0.50 vs. very large 0.45-0.41; $p<.001$). Furthermore, the fully adjusted hazards differed significantly (mHR^4, $p\leq.05$) by mother marital status (not in union, 1.00 vs. in union, 0.70; $p<.01$), region of residence (south east, 1.00 vs. south south, 0.62; $p<.001$), place of residence (rural, 1.00 vs. urban, 0.84; $p<.05$), distance to facility (big challenge, 1.00 vs. not a big challenge, 1.21; $p<.01$) and prenatal care visit (none, 1.00 vs. one/more, 0.71; $p<.01$).

Discussion

The study attempts to investigate how three key fertility-related risk factors- maternal age at childbirth, preceding birth interval and birth order-interact to determine a child's risk status at birth and the associated hazards of dying during infancy. Evidence from this study established significant disparities in infant mortality risks across risk dimensions. In aggregate, the chances of dying during infancy were significantly higher for children born in unavoidable first-order risk context and highest among those born in avoidable high-risk circumstances proportionate to their peers born in non-high-risk situation. At the first level of disaggregation, the study revealed a corresponding dose-response excess mortality risks among children having avoidable single-, double- and triple-factor high-risk attributes compared with their reference counterparts. Besides, children born with unavoidable first-order risk attribute were more likely to die in infancy than those born in single avoidable high-risk context. The Kaplan-Meier hazards plots illustrated these differentials and further showed, in conformity with other studies[5,9], that children were most at risk of dying during neonatal period as evident in the sharp drop in survival curve during this period and steady drop afterwards. These observed patterns of risks of infant death by aggregate risk groups are in agreement with findings from previous studies[1,5].

Examination of mortality risks patterns within each aggregate risk group constituents revealed considerable mix of evidence as per risks associated with specific risk attributes. For instance, across the constituents, young maternal age and joint young maternal age and close spacing emerged the utmost predisposing attributes within avoidable single- and double-factor high-risk clusters respectively, while a combination of old mother, short interval and high order characteristics predicted the most pronounced hazards of infant death across the spectrum compared with the reference non-high-risk attribute. In contrast, single old mother attribute and combined old mother-first order attributes were respectively associated with the least mortality risks within avoidable single- and double-factor high-risk constituent groups with consistently insignificant difference from comparable risks in the reference group.

Besides, the study showed that firstborns having hypothetically "protective" middle-age mother attribute suffered greater hazards of infant mortality than firstborns having hypothetically "risky" old mother attribute. However, first-order children were far more likely to die in infancy if mothers were young than if mothers were of middle or old childbearing age. These findings compare substantially with previously reported results based on larger pool of data[5]. This study established that although close birth spacing, first and high birth orders expose a child to elevated mortality risks during infancy, early childbearing significantly raises the likelihood of infant deaths than childbearing in any other reproductive age range.

Previous research have linked increased risks of childhood deaths with early and late childbearing, extremes of birth order and close birth spacing with temporal and spatial variations in degrees of influence on newborn survival[4–13]. Scholars adduced that high birth complications, physiological depletion and nutritional inadequacies associated with extreme childbearing age, increased congenital malformation, vertical disease transmission and disrupted lactation attributable to close spacing as well as parity-related competition among siblings as some of the factors that could plausibly explain higher mortality vulnerability among children born in the avoidable high-risk contexts[13,24,25].

More importantly, this study further proved that the set and number of correlates taken into consideration have significant but varied effects on infant mortality risks disparities relative to child's risk status at birth. For example, the high infant mortality risks for children of young mothers were found to attenuate when additional child and mother characteristics were adjusted for; the risks further diminished and became insignificant when all the covariates were jointly taken into account. It could be argued, based on this evidence, that equitable access to resources and life-saving healthcare have the potential to moderate childhood mortality risks related to early childbearing.

It could also be observed that modifying for child bio-demographic covariates resulted in marginal decrease in hazards of dying among high order children, whereas the risks accentuated significantly when maternal characteristics were adjusted for. Furthermore, the risks experienced by children with dual short interval-high order and triple old mother-short interval-high order attributes waned when child bio-demographic and healthcare indicators were respectively taken into consideration; whereas controlling for mother/household's demographic and socioeconomic covariates amplified the groups' risks of dying in infancy relative to those born free of high-risk attributes. These suggest that factors such as mother marital, education and wealth status as well as place of residence play more important roles in high order children's survival during infancy than child-specific and obstetric care factors.

Besides, this study adds to body of literature that have identified child's sex[6–8,10,15], birth type[6,10,12,18] and birth size[8,17,19] as key drivers of infant mortality, as risks of death were significantly higher among male, non-singleton and small birth-size children than their peers with opposite characteristics. The consistent excess risks of deaths among males suggested that physiological and genetic factors rather than socioeconomic factors underscore the observed sex differentials in mortality risks in Nigeria. As have been reported[6,17], barring a circumstance in which cultural preference for male child exposes female child to increased mortality risks, early neonatal medical conditions to which males are biologically more susceptible contribute significantly to females' survival advantage in infancy over males[6,17].

Also, this investigation agrees with extant studies linking childhood mortality to mother's marital status[7], education[6–9,12,15], region and place of residence[8,9,15,16], wealth status[8,9,15], household's size[12], prenatal healthcare utilization[9,12,19,21]. This affirms the significant health and survival benefits that accrue to children through mothers' socioeconomic status, location of residence and healthcare utilization. It is not unexpected that women who are educated, married and residents in urban centres would be better positioned to access and utilize reproductive and child health services which are vital to optimizing health and improving survival outcomes for both mother and child[6,7,9,15]. Likewise, spatial differential in women's socioeconomic status as well as fertility and health-seeking behaviours underpins regional differences in infants' risks of dying[1,7,9]. Lastly, perceived ease of geographic access to healthcare did not translate to reduced mortality risks in contrast to findings from other investigations[7,21]. It suffices to state that unobserved effects of the difference in quality of healthcare services available to mothers and of the extent to which they effectively utilize such services could explain the unexpected facility distance-infant mortality risks relationship found in this study.

Conclusion

The risks of dying in infancy differed significantly by risk attributes at birth, while children whose births occurred in multiple high-risk contexts suffered the most risk. This study adds to the discourse on the nexus between fertility behaviour and child survival, especially in Nigeria, by establishing that types of covariates considered in model estimation bear significantly on pattern of infant mortality risks associated with child's risk attribute at birth. Moreover, infant mortality risks are mostly influenced by bio-demographic factors.

Policy Implications and Recommendation for Future Research

The findings from this study underscore the imperative for policy formulation and actionable interventions targeted at achieving zero high-risk births among women of childbearing age with the purpose of expediting improvement in infant survival and infant mortality rate in Nigeria. In addition, health system should be further strengthened to provide quality life-saving care for most-at-risk children at lowest level of service delivery while closing the demographic and socioeconomic gaps in child survival.

Furthermore, attempt should be made in future investigations based on the risk at birth dimension to examine children's level of exposure to mortality risks in other critical age segments under five years. Such studies will augment existing knowledge on the links between maternal fertility behavior and child health and survival. This study is, however, limited by common analytical and data accuracy challenges as have been documented in previous studies[16,21].

Acknowledgement

The investigators thank ICF International for permitting the use of the 2013 NDHS data for this study.

Contribution of Authors

EAI conceived and designed study, performed data analysis and drafted the manuscript. SAA led the supervision of the study. SAA and AIA assisted in improving the study analytical framework. EAI, AOO and AT revised the result section. All authors reviewed the manuscript, provided critical feedback and approved the final version of the manuscript.

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