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Risk factors for post-neonatal, infant, child, and under-five mortality in Nigeria: A pooled cross-sectional analysis

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Keywords: mortality, post-neonatal, infant, child, under-five, Nigeria

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ABSTRACT

Objectives: To identify factors associated with childhood mortality at different age ranges during the first 59 months of life in Nigeria.

Design, setting and participants: A retrospective cross sectional data of pooled 2003, 2008 and 2013 datasets of the Nigeria Demographic and Health Surveys (NDHS)**.** A multi-stage, stratified, cluster random sampling method was used to gather information on 63,844 singleton live-born infants aged 0–59 months from six geopolitical zones of Nigeria.

Main outcome measures: Post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and under-five mortality (death between birth and 59 months).

Results

Mortality information on 6,285 children aged less than 5 years included: 1,859 post-neonates aged 1–11 months; 4,113 infants aged 0–11 months; and 2,172 children aged 12-59 months. Over a 10-year period, mortality rates declined by 48% (95% confidence interval (CI): 0.38–0.71) for post-neonates 34% (95% CI: 0.52–0.83) for infants, 50% (95%CI: 0.38–0.68) for children aged 12–59 months, and 37% (95% CI: 0.52–0.76) for under-five children. Having a mother with no formal education, rural residence, and poor household were consistently associated with mortality across all four age ranges.

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Conclusion

Community-based interventions for reducing under-five deaths in Nigeria should target mothers from rural areas and mothers with low socioeconomic status.

Strengths and limitations of this study

- This study is based on nationally representative household surveys that reflect every locality in Nigeria.
- Data were pooled together to create large sample sizes of deaths reported within 5 years preceding the surveys.
- Analyses were restricted to births within 5 years of each of the surveys to reduce recall bias by mothers interviewed and to minimise bias that may have arisen from changes in household characteristics.
- Newborn dates of birth and death given by mothers may have been misreported—particularly those that had occurred a few months or years before the survey.
- Causes of death and medical conditions of children were unknown at the time of survey.

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INTRODUCTION

Globally, the mortality rate of children aged under 5 years has reduced from 90 deaths per 1,000 live births in 1990 to 48 deaths in 2012; but the rate still remains very high in sub-Saharan Africa (from 177 to 98 deaths). In 2012, approximately half the world's estimated 6.6 million deaths in children aged less than 5 years occurred in sub-Saharan Africa, and Nigeria accounted for approximately 13% of these deaths[1]. The majority of these deaths are caused by communicable diseases such as malaria, diarrhoea, measles, cholera and respiratory infections. While these deaths are both preventable and treatable, the lack of effective health intervention policies has resulted in a high under-five child mortality rate in the region.

Childhood mortality remains a major public health challenge in Nigeria, despite substantial global decline in childhood deaths. Currently, the country has the highest reported number of under-five deaths in Africa and ranks as having the second highest number (after India) worldwide. Nearly one million children aged under 5 years die in Nigeria annually, and more than 60% of these deaths occur between 1 and 59 months of life[1]. Evidence from the Nigeria Demographic and Health Surveys (NDHS) showed that over a 10-year period (from 2003 to 2013), infant mortality rates (IMR) fell by 31% (from 100 to 69 deaths per 1,000 births); post-neonatal mortality rates (PMR) dropped by approximately 40% (from 52 to 31 deaths); and child mortality rates (CMR) declined by approximately 43% (from 112 to 64 deaths). Similarly, under-five child mortality rates (U5MR) decreased by approximately 36% (from 201 to 128 deaths)[2, 3]. The current U5MR of 128 deaths per 1,000 live births reported by the NDHS implies that approximately one in every eight children aged under 5 years in Nigeria dies before having a fifth birthday—approximately 21 times the average rate for developed countries (6 deaths per 1000 live births)[1]. With this marginal reduction in

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childhood deaths, it is more likely that Nigeria will not achieve the Millennium Development Goal target of 76 deaths per 1,000 live births by 2015.

Previous studies on childhood mortality in Nigeria have included multiple births in their analyses by primarily using one single data set to examine factors associated with under-five child mortality[4-10]. However, these studies have limited generalizability, in part, because of the limited number of deaths recorded in any single NDHS. Other studies have also found that including multiple births in the analysis of factors associated with under-five child mortality may produce inaccurate mortality risk estimates compared with using only singleton births in the analysis[11-18].

This present study aimed to identify specific factors that affect childhood mortality in Nigeria in different age ranges of the first 59 months of life (infant, 0–11 months; post-neonatal, 1–11 months; child, 12–59 months; and under-five, 0–59 months); data were pooled from the 2003, 2008, and 2013 NDHS. Using pooled data provides an important framework for public health researchers and policy makers in reviewing and designing new child survival intervention strategies.

METHODS

The data sets used in this study were the 2003, 2008, and 2013 NDHS surveys, pooled together to maximise the sample sizes of deaths. Information on births and deaths of children aged younger than 5 years was obtained from 79,953 eligible women aged 15–49 years who participated in the surveys[2, 3, 19].

From these women, data on a (weighted) total of 66,154 live-born infants were obtained, including singleton and multiple births of the mothers' most recent birth within 5 years prior to the survey date. The number of live births included was 6,219 from the 2003 survey;

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28,107 from the 2008 survey; and 31,828 from 2013 survey. A total of 2,310 multiple births were excluded in the final analyses. The analyses were restricted to live births during the 5 years preceding the surveys to limit mothers' potential for differential recall of events, as deliveries had occurred at different points in time prior to the interview. Detailed sampling methods used in gathering the data have been reported elsewhere[2, 3, 19].

Study outcome variables

The main outcome variables in the study were post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and total under-five mortality (death between birth and 59 months). Each death case was coded as 1, and each non-death (alive) case was coded as 0.

Study factors

Study factors for this study were based on the Mosley and Chen framework of factors influencing child survival in developing countries;[20] other previous studies[21-27] on childhood mortality (particularly in the sub-Saharan Africa region) also played a role in the assessment of potential study variables. These variables were adapted to the data available in the merged dataset and comprised geographic location of place of residence (categorised as urban-rural residence), a household measure of income (see below) and a range of individual level factors.

Individual-level factors consisted of maternal characteristics (religion, education, literacy level, age, body mass index, occupation and desire for pregnancy); child characteristics (sex, birth place, size, mode of delivery, delivery assistance, and a combination of birth order and birth interval); and paternal education.

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The only household level factor used was the wealth index variable, which measured the economic status of the households interviewed in the survey. A principal components analysis (PCA) was used in constructing the wealth index[28]. Weights were assigned to the household facilities and assets of respondents. The facilities and assets included were those that were consistent across the pooled NDHS data: television, radio, refrigerator, car, bicycle, motorcycle, source of drinking water, type of toilet facility, electricity and type of building materials used in the place of dwelling. In the NDHS data set, the household wealth index was categorised into five quintiles: poorest, poorer, middle, richer and richest. However, in the analysis, the household wealth index was re-categorised into three groups: the bottom 40% of households were referred to as poor households, the next 40% as middle households and the top 20% as rich households.

Statistical analysis

First, an estimation of mortality rates for singleton live births in each of the measured age ranges was conducted according to the year of survey, using a method similar to that described by Rutstien and Rojas[29]. This step was followed by a multivariable analysis that independently assessed the effect of each factor for each of the study outcome variables after adjusting for potential confounding variables; Cox proportional hazard regression models were used in this assessment.

In the multivariable model for each of the study outcomes, a stepwise backwards elimination process was used. In the first step, all study factors were entered into the baseline multivariable model to examine their associations with the study outcomes. Next, a stepwise backwards elimination process was performed, and variables that were significantly associated with the study outcomes at 5% significance levels were retained in the final model. The backwards elimination process was then repeated by using a different approach to reduce

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any statistical error in our analyses. First, only variables with p-values <0.20 in the unadjusted analysis were entered for a stepwise backward elimination process. Second, we tested and reported any collinearity in the final model.

The hazard ratios (HR) and their 95% confidence intervals (CIs) obtained from the adjusted Cox proportional models were used to measure the risk of infant, post-neonatal, child, and under-five mortalities. All statistical analyses were conducted using "SVY" commands in STATA/MP version 12.0 (StataCorp, College Station, TX, USA) to adjust for the cluster sampling survey design, weights, and standard errors.

RESULTS

A weighted total of 6,285 deaths of children aged under 5 years occurred within the 5-year period preceding the survey interview dates: 1,859 between 1 month and 11 months (post-neonatal mortality); 4,113 occurred between birth and 11 months (infant mortality); and 2,172 between 12 and 59 months (child mortality). The Figure 1 presents findings from the mortality rate estimation, with 95% confidence intervals for singleton live births between 2003 and 2013 by each year of the survey for each mortality age range assessed. Over the 10-year period, IMR for singleton live born infants decreased by approximately 30%, from 84 deaths per 1000 live births in 2003 to 59 in 2013; PMR fell by approximately 40%, from 43 to 26 deaths; CMR declined by 44%, from 48 to 27 deaths; and U5MR dropped by 36%, from 132 to 85 deaths.

[Figure 1 here]

Risk factors for post-neonatal mortality (1-11 months)

As shown in Table 1, post-neonates born to younger mothers (age <20 years) reported a significantly higher risk of post-neonatal deaths (HR = 3.57, CI: 2.26–5.63) compared to

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those born to mothers aged between 30 and 39 years. Post-neonates living in rural areas were also more likely to die (HR = 1.53, CI: 1.19–1.96) than those living in urban areas. When place of residence was replaced by household wealth index in the final model, there was a significantly higher risk of post-neonatal death for those born to mothers from poor households (HR = 2.47, CI: 1.76–3.47) and middle-class households (HR = 1.93, CI: 1.40–2.67) compared to wealthy households. Other factors that were significantly associated with post-neonatal deaths included having a mother with no formal education (HR = 1.32, CI: 1.03–1.70); having a birth size that was perceived as small or smaller (HR = 1.42, CI: 1.12–1.79); and having a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.99, CI: 1.45–2.73).

Table 1. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with post-neonatal and infant mortality

Variables	Post-neonatal (1-11 months)			Infant (0-11 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.70	(0.53–0.93)	0.014	0.80	(0.64–0.99)	0.039
2013	0.52	(0.38–0.71)	<0.001	0.66	(0.52–0.83)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.48	(1.16–1.89)	0.002	1.23	(1.03–1.46)	0.023
Household wealth index						
Rich				1.00		
Middle	-	-	-	1.37	(1.12–1.67)	0.002
Poor	-	-	-	1.39	(1.11–1.73)	0.004
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.13	(0.86–1.48)	0.388	1.01	(0.95–1.39)	0.418
No education	1.30	(1.01–1.66)	0.044	1.38	(1.11–1.84)	0.039
Mother's age						
30 - 39 years	1.00			1.00		
Less than 20 years	3.45	(2.19–5.46)	<0.001	3.00	(2.25–4.01)	<0.001
20 - 29 years	1.59	(1.23–2.04)		1.31	(1.11–1.54)	0.001

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			<0.001			
40 - 49 years	1.08	(0.82–1.42)	0.578	1.08	(0.90–1.30)	0.403
Mother's perceived baby size						
Average or large	1.00			1.00		
Small or very small	1.44	(1.14–1.81)	0.002	1.72	(1.49–2.00)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs	1.00					
1st child	1.13	(0.80–1.61)	0.488	1.38	(1.10–1.72)	0.005
2nd or 3rd child, interval ≤2 yrs	1.64	(1.13–2.37)	0.009	1.52	(1.17–1.96)	0.001
4th or higher child, interval>2 yrs	1.39	(1.05–1.85)	0.024	1.30	(1.06–1.60)	0.012
4th or higher child, interval≤ 2 yrs	1.89	(1.38–2.59)	<0.001	1.93	(1.56–2.40)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.23	(1.09–1.39)	0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section˟	-	-	-	1.75	(1.24–2.46)	0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ˟Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for infant mortality (0-11 months)

Findings in Table 1 indicate that being born to mothers from poor households (HR = 1.42, CI: 1.14–1.77) and middle-class households (HR = 1.33, CI: 1.14–1.69) had a higher risk of infant mortality than wealthy households. Infants whose birth size was perceived as small or smaller had a 1.71 times greater risk of dying than those perceived as average or larger in size. Male infants were also more likely to die (HR = 1.23, CI: 1.09–1.39) than female infants, as were infants living in rural areas (HR = 1.24, CI: 1.04–1.48). Other significant factors that affected infant mortality included infants born to mothers <20 years old (HR = 3.06, CI: 2.29–4.09); infants of fourth or higher birth order with a birth interval ≤ 2 years (HR = 1.97, CI: 1.59–2.45); infants of illiterate mothers (HR = 1.38, CI: 1.11–1.84); and infants whose deliveries occurred by Caesarean section (HR = 1.75, CI: 1.25–2.46).

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Risk factors for child mortality (age 12–59 months)

As indicated in Table 2, children aged between 12 and 59 months had a significantly higher risk of child mortality if their mothers had either no formal education (HR = 2.16, CI: 1.58–2.94) or else had only a primary education (HR = 1.61, CI: 1.16–2.24). Similar findings were observed when we replaced maternal education with paternal education in the final model; children whose fathers had no formal education were more likely to die (HR = 1.73, CI: 1.34–2.22). Children from poor households were also more likely to die (HR = 1.81, CI: 1.25–2.62), as were children whose mothers resided in rural areas (HR = 1.55, CI: 1.19–2.03).

Table 2. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with child and under-five mortality

Variables	Child (12-59 months)			Under-5 (0-59 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.71	(0.54–0.93)	0.015	0.75	(0.63–0.90)	0.002
2013	0.50	(0.38–0.68)	<0.001	0.63	(0.52–0.76)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.52	(1.16–1.99)	0.002	1.29	(1.11–1.50)	0.001
Household wealth index						
Rich	1.00			1.00		
Middle	1.63	(1.14–2.32)	0.007	1.42	(1.18–1.70)	<0.001
Poor	1.72	(1.19–2.49)	0.004	1.43	(1.17–1.76)	0.001
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.58	(1.13–2.20)	0.007	1.11	(0.93–1.32)	0.244
No education	2.13	(1.56–2.89)	<0.001	1.19	(1.02–1.41)	0.032
Mother's age						
30 - 39 years				1.00		
Less than 20 years	-	-	-	1.44	(1.13–1.85)	0.004
20 - 29 years	-	-	-	1.04	(0.92–1.19)	0.519
40 - 49 years	-	-	-	1.47	(1.27–1.71)	

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						<0.001
Mother's perceived baby size						
Average or large				1.00		
Small or very small	-	-	-	1.47	(1.29─1.68)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs						
1st child	-	-	-	1.42	(1.17─1.71)	<0.001
2nd or 3rd child, interval ≤2 yrs	-	-	-	1.48	(1.19─1.84)	<0.001
4th or higher child, interval>2 yrs	-	-	-	1.10	(0.93─1.30)	0.288
4th or higher child, interval≤ 2 yrs	-	-	-	1.89	(1.58─2.26)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.24	(1.12─1.38)	<0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section×	-	-	-	1.74	(1.25─2.42)	0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ×Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for under-five mortality (age 0–59 months)

Multivariable analyses (Table 2) indicated significant associations with under-five mortality in those of a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.91, CI: 1.60–2.29); children of a second or third higher birth order with a short birth interval ≤2 years were also more likely to die (HR = 1.49, CI: 1.20–1.85). Additional associations included having a mother aged <20 years (HR = 1.47, CI: 1.15–1.89) and having a mother with no formal education (HR = 1.22, CI: 1.04–1.43). Children from poor households were about one and a half times as likely to die within 59 months of life as those from rich household (HR = 1.47, CI: 1.20–1.80). Other significant factors that influenced a child's under-five mortality included having a birth size that was perceived by the mother to be smaller than the average size (HR = 1.47, CI: 1.28–1.67); being of the male gender (HR = 1.25, CI: 1.13–1.38); having

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had a caesarean section delivery (HR = 1.74, CI: 1.26–2.41); and residing in rural rather than urban areas (HR = 1.30, CI: 1.12–1.52).

DISCUSSION

We found that over the past 10 years, there has been a steady decline in the rates of infant, post-neonatal, child, and under-five mortalities in Nigeria. While this trend shows that Nigeria is making progress, the pace of this progress still remains too slow to achieve the Millennium Development Goal of reducing Nigeria's child mortality to 76 deaths per 1,000 live births by the year 2015.

The findings from this present study show that child mortality risk factors were consistent across each of the four age ranges, and related to living in a poor household; living in a rural area; and having a mother with no schooling. Infant, post-neonatal and under-five deaths were also associated with having a younger mother (< 20 years); being perceived as a small or very small newborn by their mothers; and having a higher birth order with a birth interval ≤2 years. Previous delivery by caesarean section and being of the male gender were significantly associated with infant and under-five child mortality.

Our study's findings of greater mortality risk for children of all four age ranges living in poor households are similar to those reported in earlier reviews. Economic status has been reported as having a great impact on children, particularly those in the post-neonatal stage[30-32]. In Nigeria, more than two-thirds of the population live below the international poverty line of $1.25 per day[33]. Such poverty limits the opportunities for most mothers to access appropriate healthcare services for their children, resulting in a high probability of infant and child death.

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Past studies have also shown that there are high risks of mortality amongst children aged less than 5 years whose mothers had no schooling[31, 34-36]. Our study also found that children of mothers with no schooling are at a greater risk of death across all four age groups compared with those whose mothers had a secondary or higher level of education. Educated mothers are more likely to have better knowledge about child health and modern healthcare services, and is a key determinant of poor child health[37]. Improved maternal healthcare-seeking behaviours,[38,39] such as immunisation and feeding practices, may in turn positively influence child survival. Educated mothers are additionally more likely to reside in socially and economically developed areas that have well-equipped medical facilities and good water and sanitation infrastructure[40].

In this study, we noted that children aged under 5 years born to mothers living in rural areas had a higher mortality risk compared with those living in urban areas. This result differs from previous study conducted in Tanzania in 1995, which found no relationship between place of residence and childhood mortality. The finding in Tanzania was the result of successful implementation of policies that had empowered rural communities through the provision of health facilities, basic education and safe water supply[41]. The significantly higher risk of death among children who live in rural areas in Nigeria found in the present study may be attributed to limited access to healthcare facilities, poor educational and transport services, unavailability of a safe water supply and inadequate basic sanitation facilities. Such conditions disproportionally hinder rural dwellers from receiving adequate healthcare and social and economic services, which adversely affect child survival[42].

Children born to mothers younger than 20 years of age were at a greater risk of infant, post-neonatal, and under-five mortality. Factors contributing to this finding could include physical immaturity, pregnancy complications, poor nutritional status, inadequate use of maternal health services, and inexperience in child rearing among younger mothers[43].

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The risks of infant and under-five mortalities were significantly higher for male children than for female children; post-neonatal and child mortalities did not significant differ by gender in the multivariate analyses. Biological factors[44-46] may be possible explanations to the increased risk of male deaths. Late male development of fatal lung maturity in the first week of life,[47] for example, results in a higher incidence of respiratory diseases in male individuals compared with female individuals.

Findings from this study indicate that children of fourth or higher birth order born with shorter birth intervals (≤2 years) were at a greater risk of dying at infant, post-neonatal, and under-five ages. This result is consistent with previous studies,[48-50] and may reflect that short-interval births may adversely affect a maternal health and wellbeing, economic resource competition among infants, particularly in poorer households[48]. We also found that the risk of infant, post-neonatal, and under-five mortality was significantly higher for children whose mother perceived their size to be small or very small after birth compared with those who were perceived as average or larger size. This observation may be explained by the influence of biologically associated risk factors such as low birth weight, poor nutritional status and prematurity[51, 52].

CONCLUSION

This study found that under-five mortality has declined significantly by 37% over a 10-year period after adjusting for individual, household and community level factors. Our findings indicated that living in poor households, living in rural areas and having mothers with no schooling are common significant risk factors for mortality across all four age ranges (infant, post-neonatal, child and under-five) in Nigeria. Community-based interventions that target mothers living in rural areas and mothers with low socioeconomic status are needed for improving child survival in Nigeria.

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Contributors

EOK and AKE were involved in the conception and design of this study. EOK conducted the literature review, carried out the analysis and drafted the manuscript. AKE, DMJ, HJ and PAN provided advice on interpretation and revised and edited the manuscript. All authors read and approved the manuscript.

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Data sharing statement No additional data are available

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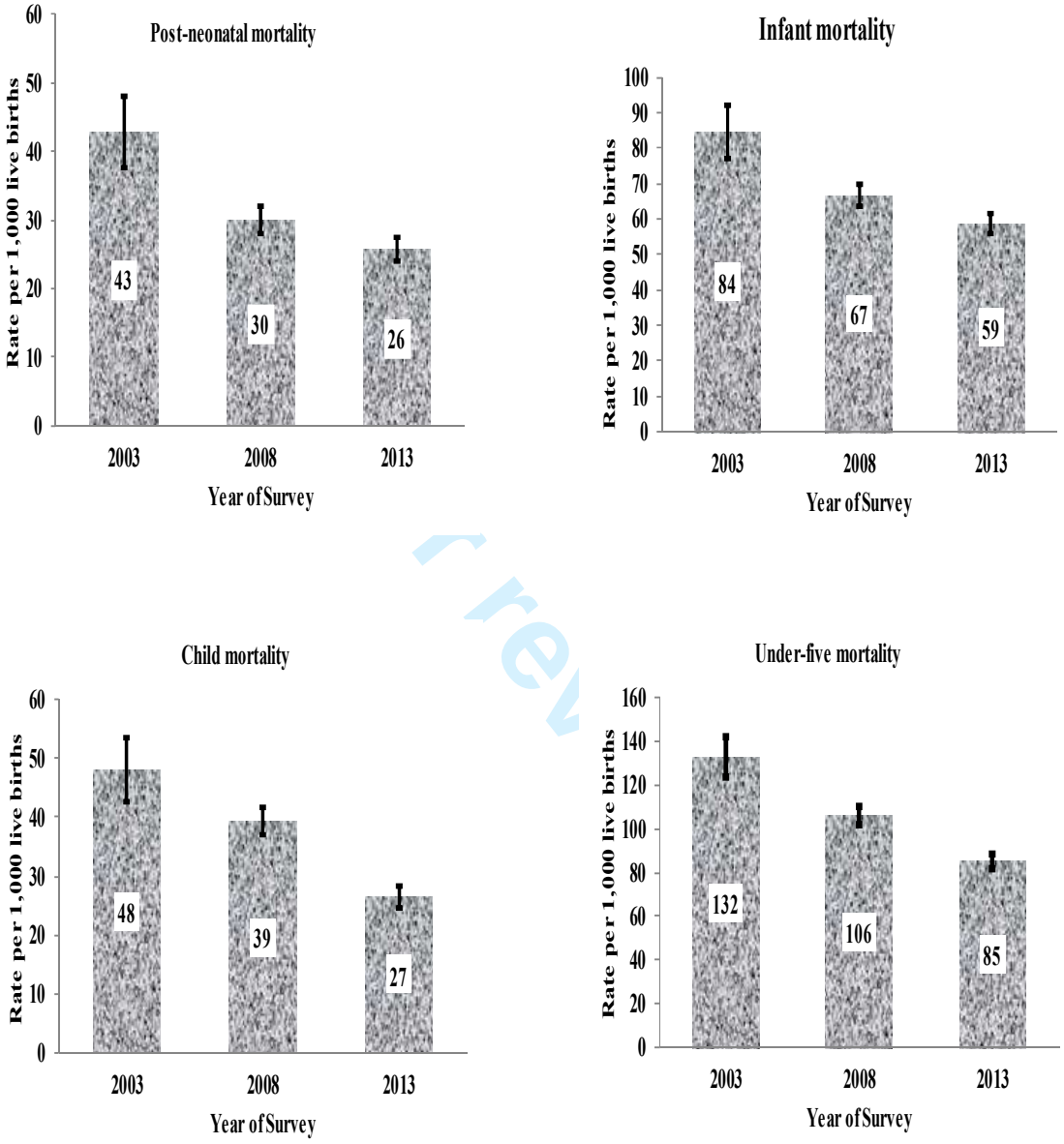
Figure1. Post-neonatal, infant, child and under-five deaths per 1,000 live-births (singleton), with 95% confidence interval by year of NDHS survey, 2003–2013.



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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Risk factors for post-neonatal, infant, child, and under-five mortality in Nigeria: A pooled cross-sectional analysis

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Risk factors for post-neonatal, infant, child, and under-five mortality in Nigeria: A pooled cross-sectional analysis

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Keywords: mortality, post-neonatal, infant, child, under-five, Nigeria

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ABSTRACT

Objectives: To identify common factors associated with post-neonatal, infant, child, and under-five mortality in Nigeria.

Design, setting and participants: A cross sectional data of three Nigeria Demographic and Health Surveys (NDHS) for the years 2003, 2008 and 2013 were used. A multi-stage, stratified, cluster random sampling method was used to gather information on 63,844 singleton live-born infants of the most recent birth of a mother within a 5-year period before each survey was examined using cox regression models.

Main outcome measures: Post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and under-five mortality (death between birth and 59 months).

Results

Multivariable analyses indicated that children born to mothers with no formal education was significantly associated with mortality across all four age ranges (Adjusted hazard ratios (HR) =1.30, 95% confidence interval (CI): 1.01– 1.66 for post-neonatal, HR= 1.38, 95% CI: 1.11– 1.84 for infant, HR= 2.13, 95% CI: 1.56– 2.89 for child, and HR= 1.19, 95% CI: 1.02– 1.41 for under-five). Other significant factors included living in rural areas (HR= 1.48, 95% CI: 1.16– 1.89 for post-neonatal, HR= 1.23, 95% CI: 1.03– 1.47 for infant, HR= 1.52, 95% CI: 1.16– 1.99 for child, and HR= 1.29, 95% CI: 1.11– 1.50 for under-five), and poor household

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(HR= 2.47, 95% CI: 1.76– 3.47 for post-neonatal, HR= 1.40, 95% CI: 1.10– 1.78 for infant, HR= 1.72, 95% CI: 1.19– 2.49 for child, and HR= 1.43, 95% CI: 1.17– 1.76 for under-five).

Conclusion

This study found that no formal education, poor households and living in rural areas increased the risk of post-neonatal, infant, child and under-five mortality among Nigerian children. Community-based interventions for reducing under-five deaths are needed and should target children born to mothers of low socioeconomic status.

Strengths and limitations of this study

- This study is based on nationally representative household surveys that reflect every locality in Nigeria.
- Data were pooled together to create large sample sizes of deaths reported within 5 years preceding the surveys.
- Analyses were restricted to births within 5 years of each of the surveys to reduce recall bias by mothers interviewed and to minimise bias that may have arisen from changes in household characteristics.
- Newborn dates of birth and death given by mothers may have been misreported—particularly those that had occurred a few months or years before the survey.
- Causes of death and medical conditions of children were unknown at the time of survey.

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INTRODUCTION

Globally, the mortality rate of children aged under 5 years has reduced from 90 deaths per 1,000 live births in 1990 to 48 deaths in 2012; but the rate still remains very high in sub-Saharan Africa (from 177 to 98 deaths). In 2012, approximately half the world's estimated 6.6 million deaths in children aged less than 5 years occurred in sub-Saharan Africa, and Nigeria accounted for approximately 13% of these deaths.[1] The majority of these deaths are caused by communicable diseases such as malaria, diarrhoea, measles, cholera and respiratory infections. While these deaths are both preventable and treatable, the lack of effective health intervention policies has resulted in a high under-five child mortality rate in the region.

Childhood mortality remains a major public health challenge in Nigeria, despite substantial global decline in childhood deaths. Currently, the country has the highest reported number of under-five deaths in Africa and ranks as having the second highest number (after India) worldwide. Nearly one million children aged under 5 years die in Nigeria annually, and more than 60% of these deaths occur between 1 and 59 months of life.[1] Evidence from the Nigeria Demographic and Health Surveys (NDHS) showed that over a 10-year period (from 2003 to 2013), infant mortality rates (IMR) fell by 31% (from 100 to 69 deaths per 1,000 births); post-neonatal mortality rates (PMR) dropped by approximately 40% (from 52 to 31 deaths); and child mortality rates (CMR) declined by approximately 43% (from 112 to 64 deaths). Similarly, under-five child mortality rates (U5MR) decreased by approximately 36% (from 201 to 128 deaths).[2, 3] The current U5MR of 128 deaths per 1,000 live births reported by the NDHS implies that approximately one in every eight children aged under 5 years in Nigeria dies before having a fifth birthday—approximately 21 times the average rate for developed countries (6 deaths per 1000 live births).[1] With this marginal reduction in

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childhood deaths, it is more likely that Nigeria will not achieve the Millennium Development Goal target of 76 deaths per 1,000 live births by 2015.

Previous studies on childhood mortality in Nigeria have included multiple births in their analyses by primarily using one single data set to examine factors associated with under-five child mortality.[4-10] However, these studies have limited generalizability, in part, because of the limited number of deaths recorded in any single NDHS. Other studies have also found that including multiple births in the analysis of factors associated with under-five child mortality may produce inaccurate mortality risk estimates compared with using only singleton births in the analysis.[11-18]

Inadequate health facilities, insufficient skilled health professionals, and lack of modern medical equipment have undermined the Nigerian healthcare system, particularly in rural areas.[19] As a result, the Nigerian government launched and implemented National Health Policy (NHP) and Ward Health System (WHS) whose core targets include reduction of under-five mortality rate.[3] Despite all these initiatives, deaths of children < 5 years of age still remain high in Nigeria. Hence, this present study aimed to identify common factors that affect childhood mortality in Nigeria in different age ranges of the first 59 months of life (infant, 0–11 months; post-neonatal, 1–11 months; child, 12–59 months; and under-five, 0–59 months). Using pooled data may provide an important framework for public health researchers and policy makers in reviewing and designing new child survival intervention strategies.[20]

METHODS

The data sets used in this study were the 2003, 2008, and 2013 NDHS surveys, pooled together to maximise the sample sizes of deaths. Information on births and deaths of children

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aged younger than 5 years was obtained from 79,953 eligible women aged 15–49 years who participated in the surveys.[2, 3, 21]

From these women, data on a (weighted) total of 66,154 live-born infants were obtained, including singleton and multiple births of the mothers' most recent birth within 5 years prior to the survey date. The number of live births included was 6,219 from the 2003 survey; 28,107 from the 2008 survey; and 31,828 from 2013 survey. A total of 2,310 multiple births were excluded in the final analyses. The analyses were restricted to live births and most recent births during the 5 years preceding the surveys to limit mothers' potential for differential recall of events, as deliveries had occurred at different points in time prior to the interview. Detailed sampling methods used in gathering the data have been reported elsewhere.[2, 3, 21]

Study outcome variables

The main outcome variables in the study were post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and total under-five mortality (death between birth and 59 months). Each death case was coded as 1, and each non-death (alive) case was coded as 0.

Study factors

Study factors for this study were based on the Mosley and Chen framework of factors influencing child survival in developing countries;[22] other previous studies [23-29] on childhood mortality (particularly in the sub-Saharan Africa region) also played a role in the assessment of potential study variables. These variables were adapted to the data available in the merged dataset and comprised geographic location of place of residence (categorised as

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urban-rural residence), a household measure of income and a range of individual level factors.

Individual-level factors consisted of maternal characteristics (religion, education, literacy level, age, body mass index, occupation and desire for pregnancy); child characteristics (sex, birth place, size, mode of delivery, delivery assistance, and a combination of birth order and birth interval); and paternal education.

The only household level factor used was the wealth index variable, which measured the economic status of the households interviewed in the survey. A principal components analysis (PCA) was used in constructing the wealth index.[30] Weights were assigned to the household facilities and assets of respondents. The facilities and assets included were those that were consistent across the pooled NDHS data: television, radio, refrigerator, car, bicycle, motorcycle, source of drinking water, type of toilet facility, electricity and type of building materials used in the place of dwelling. In the NDHS data set, the household wealth index was categorised into five quintiles: poorest, poorer, middle, richer and richest. However, in the analysis, the household wealth index was re-categorised into three groups: the bottom 40% of households were referred to as poor households, the next 40% as middle households and the top 20% as rich households.

Statistical analysis

First, an estimation of mortality rates for singleton live births in each of the measured age ranges was conducted according to the year of survey, using a method similar to that described by Rutstien and Rojas.[31] This step was followed by a multivariable analysis that independently assessed the effect of each factor for each of the study outcome variables after adjusting for potential confounding variables; Cox proportional hazard regression models were used in this assessment.

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The multivariable analysis model for each of the study outcomes performed used a stepwise backwards elimination process to identify independent variables that were significantly associated with the study outcomes. To reduce any statistical error in our analyses, we double checked our backward elimination method by using the following procedures: (1) we entered only potential risk factors with a p value < 0.20 obtained in the univariable analysis for backward elimination process, (2) we tested the backward elimination by including all of the variables (all potential confounding factors), and (3) we tested and reported any collinearity in the final model.

The hazard ratios (HR) and their 95% confidence intervals (CIs) obtained from the adjusted Cox proportional models were used to measure the effect of predictor variables with the study outcomes (infant, post-neonatal, child, and under-five deaths). All statistical analyses were conducted using "SVY" commands in STATA/MP version 12.0 (StataCorp, College Station, TX, USA) to adjust for the cluster sampling survey design, weights, and standard errors.

RESULTS

A weighted total of 6,285 deaths of children aged under 5 years occurred within the 5-year period preceding the survey interview dates: 1,859 between 1 month and 11 months (post-neonatal mortality); 4,113 occurred between birth and 11 months (infant mortality); and 2,172 between 12 and 59 months (child mortality). The distribution of 6,285 children who died before their fifth birthday according to community, individual and household level characteristics are presented in Table 1. In the pooled NDHS data, more than 74% of the post-neonatal, infant, child and under-five deaths occurred in the rural areas. Delivery assisted by non-health professionals had the highest percent of deaths compared with health professionals (56.4% post-neonatal, 51.2% infant, 65.6% child, and 56.1% under-five).

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Table 1. Distribution of post-neonatal, infant, child and under-five mortality, reported in three demographic and health surveys in Nigeria, 2003 – 2013 (N=6,285).

Variables	Post-neonatal n (%)	Infant n (%)	Child n (%)	Under-five n (%)
Community level factors				
Residence type				
Urban	444 (23.9)	1042 (25.3)	379 (17.4)	1421 (22.6)
Rural	1416 (76.1)	3071 (74.7)	1793(82.6)	4864 (77.4)
Geopolitical zone				
North Central	250 (13.5)	521 (12.7)	211 (9.7)	732 (11.6)
North East	377 (20.3)	806 (19.6)	486 (22.4)	1291 (20.5)
North West	721 (38.8)	1530 (37.2)	1052(48.5)	2583 (41.1)
South East	193 (10.4)	405 (9.9)	135 (6.2)	540 (8.6)
South West	174 (9.4)	438 (10.6)	169 (7.8)	607 (9.7)
South South	143 (7.7)	413 (10.0)	119 (5.5)	533 (8.5)
Household wealth index				
Poor	845 (45.4)	1784 (43.4)	1088(50.1)	2872 (45.7)
Middle	760 (40.9)	1658 (40.3)	867 (39.9)	2525 (40.2)
Rich	254 (13.7)	671 (16.3)	218 (10.0)	889 (14.1)
Individual related factors				
Mother's religion[x]				
Traditionalist and other	190 (10.3)	366 (9.0)	252 (11.6)	618 (9.9)
Islam	1030 (55.7)	2226 (54.4)	1410(65.0)	3636 (58.1)
Catholic and other Christian	618 (33.4)	1472 (36.0)	495 (22.8)	1966 (31.4)
Mother's age at birth				
< 20	125 (6.7)	322 (7.8)	91 (4.2)	413 (6.6)
20-29	886 (47.7)	1929 (46.9)	1023(47.1)	2952 (47.0)
30-39	641 (34.5)	1394 (33.9)	780 (35.9)	2174 (34.6)
40-49	206 (11.1)	468 (11.4)	278 (12.8)	746 (11.9)
Mother's education				
No education	1078 (58.0)	2213 (53.8)	1435(66.1)	3648 (58.0)
Primary	382 (20.5)	917 (22.3)	432 (19.9)	1350 (21.5)
Secondary or higher	399 (21.5)	983 (23.9)	305 (14.0)	1287 (20.5)
Mother's literacy level[x]				
Cannot read at all	1312 (70.6)	2755 (67.0)	1691(77.9)	4446 (70.7)
Able to read	542 (29.1)	1330 (32.3)	465 (21.4)	1795 (28.6)
Mother's desire for pregnancy[x]				
Wanted then	1611 (86.6)	3541 (86.1)	1909(87.9)	5450 (86.7)
Wanted later	112 (6.1)	234 (5.7)	107 (4.9)	341 (5.4)
Wanted no more	53 (2.9)	124 (3.02)	48 (2.2)	172 (2.7)
Mother's body mass index[x]				
Greater than 18.5	1621 (87.2)	3634 (88.3)	1892(87.1)	5526 (87.9)
Less than or equal to 18.5	201 (10.8)	408 (9.9)	241 (11.1)	650 (10.3)
Mother's working status[x]				
Not working	632 (35.2)	1402 (35.4)	784 (37.2)	2186 (36.0)

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Working	1158 (64.5)	2548 (64.3)	1320(62.6)	3867 (63.7)
Father's education[¤]				
No education	865 (46.5)	1762 (42.8)	1151(53.0)	2913 (46.4)
Primary	388 (20.9)	867 (21.1)	450 (20.7)	1316 (20.9)
Secondary or higher	552 (29.7)	1360 (33.1)	509 (23.5)	1869 (29.7)
Sex of child				
Female	887 (47.7)	1838 (44.7)	1057(48.7)	2895 (46.1)
Male	973 (52.3)	2275 (55.3)	1115(51.3)	3390 (53.9)
Mother's perceived baby size[¤]				
Small or very small	301 (16.2)	795 (19.3)	352 (16.2)	1148 (18.3)
Average or larger	1446 (77.8)	3006 (73.1)	1702(78.4)	4708 (74.9)
Birth order and birth interval				
First child	347 (18.7)	947 (23.0)	370 (17.0)	1317 (21)
2 or 3 child, interval > 2	337 (18.1)	699 (17.0)	398 (18.3)	1098 (17.5)
2 or 3 child, interval <= 2	229 (12.3)	497 (12.1)	218 (10.0)	715 (11.4)
4 or more child, interval > 2	542 (29.1)	1114 (27.1)	700 (32.2)	1814 (28.9)
4 or more child, interval <= 2	404 (21.7)	856 (20.8)	486 (22.4)	1341 (21.3)
Mode of delivery[¤]				
Non-caesarean	1831 (98.5)	3978 (96.7)	2149(98.9)	6127 (97.5)
Caesarean section	17 (0.9)	103 (2.5)	13 (0.6)	115 (1.8)
Delivery assistance[¤]				
Health professional	493 (26.5)	1307 (31.8)	411 (18.9)	1718 (27.3)
non-Health professional	1049 (56.4)	2104 (51.2)	1424(65.6)	3528 (56.1)
Birth place of child[¤]				
Health facility	271 (25.3)	1239 (30.1)	386 (17.8)	1625 (25.9)
Home	1307 (70.3)	2673 (65.0)	1693(78.0)	4367 (69.5)

N, Weighted total; [¤]Percentages did not add up to 100% because of missing values; n (%), frequency (and proportion dead) across variables.

Between 2003 and 2013, IMR for singleton live born infants decreased by approximately 30%, from 84 deaths per 1000 live births in 2003 to 59 in 2013; PMR fell by approximately 40%, from 43 to 26 deaths; CMR declined by 44%, from 48 to 27 deaths; and U5MR dropped by 36%, from 132 to 85 deaths (Figure 1).

[Figure 1 here]

Risk factors for post-neonatal mortality (1-11 months)

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Post-neonates born to younger mothers (age <20 years) reported a significantly higher risk of post-neonatal deaths (HR = 3.45, CI: 2.19–5.46) compared to those born to mothers aged between 30 and 39 years. Post-neonates living in rural areas were also more likely to die (HR = 1.48, CI: 1.16–1.89) than those living in urban areas. When place of residence was replaced by household wealth index in the final model, there was a significantly higher risk of post-neonatal death for those born to mothers from poor households (HR = 2.47, CI: 1.76–3.47) and middle-class households (HR = 1.93, CI: 1.40–2.67) compared to wealthy households. Other factors that were significantly associated with post-neonatal deaths included having a mother with no formal education (HR = 1.30, CI: 1.01–1.66); having a birth size that was perceived as small or smaller (HR = 1.44, CI: 1.14–1.81); and having a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.92, CI: 1.40–2.64) (Table 2).

Table 2. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with post-neonatal and infant mortality

Variables	Post-neonatal (1-11 months)			Infant (0-11 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.70	(0.53–0.93)	0.014	0.80	(0.64–0.99)	0.038
2013	0.52	(0.38–0.71)	<0.001	0.66	(0.53–0.83)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.48	(1.16–1.89)	0.002	1.23	(1.03–1.47)	0.023
Household wealth index						
Rich				1.00		
Middle	-	-	-	1.37	(1.11–1.69)	0.003
Poor	-	-	-	1.40	(1.10–1.78)	0.006
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.13	(0.86–1.48)	0.388	1.01	(0.95–1.39)	0.418
No education	1.30	(1.01–1.66)	0.044	1.38	(1.11–1.84)	0.039
Mother's age						
30 - 39 years	1.00			1.00		
Less than 20 years	3.45	(2.19–5.46)	<0.001	3.04	(2.28–4.05)	<0.001
20 - 29 years	1.59	(1.23–2.04)	<0.001	1.31	(1.12–1.54)	0.001
40 - 49 years	1.08	(0.82–1.42)	0.578	1.09	(0.90–1.31)	0.385

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Mother's perceived baby size						
Average or large	1.00			1.00		
Small or very small	1.44	(1.14–1.81)	0.002	1.74	(1.50–2.02)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs	1.00					
1st child	1.13	(0.80–1.61)	0.488	1.38	(1.10–1.72)	0.005
2nd or 3rd child, interval ≤2 yrs	1.64	(1.13–2.37)	0.009	1.52	(1.18–1.97)	0.001
4th or higher child, interval>2 yrs	1.39	(1.05–1.85)	0.024	1.30	(1.06–1.60)	0.014
4th or higher child, interval≤ 2 yrs	1.92	(1.40–2.64)	<0.001	1.94	(1.56–2.41)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.23	(1.09–1.39)	0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section˟	-	-	-	1.74	(1.24–2.45)	<0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ˟Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for infant mortality (0-11 months)

Infants born to mothers from poor households (HR = 1.40, CI: 1.10–1.78) and middle-class households (HR = 1.37, CI: 1.11–1.69) had a higher risk of infant mortality than wealthy households. Infants whose birth size was perceived as small or smaller had a 1.74 times greater risk of dying than those perceived as average or larger in size. Male infants were also more likely to die (HR = 1.23, CI: 1.09–1.39) than female infants, as were infants living in rural areas (HR = 1.23, CI: 1.03–1.47). Other significant factors that affected infant mortality included infants born to mothers <20 years old (HR = 3.04, CI: 2.28–4.05); infants of fourth or higher birth order with a birth interval ≤ 2 years (HR = 1.94, CI: 1.56–2.41); infants of illiterate mothers (HR = 1.38, CI: 1.11–1.84); and infants whose deliveries occurred by Caesarean section (HR = 1.74, CI: 1.24–2.45) (Table 2).

Risk factors for child mortality (age 12–59 months)

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Children aged between 12 and 59 months had a significantly higher risk of child mortality if their mothers had either no formal education (HR = 2.13, CI: 1.56–2.89) or else had only a primary education (HR = 1.58, CI: 1.13–2.20). Similar findings were observed when we replaced maternal education with paternal education in the final model; children whose fathers had no formal education were more likely to die (HR = 1.73, CI: 1.34–2.22). Children from poor households were also more likely to die (HR = 1.72, CI: 1.19–2.49), as were children whose mothers resided in rural areas (HR = 1.52, CI: 1.16–1.99) (Table 3).

Table 3. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with child and under-five mortality

Variables	Child (12-59 months)			Under-5 (0-59 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.71	(0.54–0.93)	0.015	0.75	(0.63–0.90)	0.002
2013	0.50	(0.38–0.68)	<0.001	0.63	(0.52–0.76)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.52	(1.16–1.99)	0.002	1.29	(1.11–1.50)	0.001
Household wealth index						
Rich	1.00			1.00		
Middle	1.63	(1.14–2.32)	0.007	1.42	(1.18–1.70)	0.001
Poor	1.72	(1.19–2.49)	0.004	1.43	(1.17–1.76)	0.001
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.58	(1.13–2.20)	0.007	1.11	(0.93–1.32)	0.244
No education	2.13	(1.56–2.89)	<0.001	1.19	(1.02–1.41)	0.032
Mother's age						
30 - 39 years				1.00		
Less than 20 years	-	-	-	1.44	(1.13–1.85)	0.004
20 - 29 years	-	-	-	1.04	(0.92–1.19)	0.519
40 - 49 years	-	-	-	1.47	(1.27–1.71)	<0.001
Mother's perceived baby size						
Average or large				1.00		
Small or very small	-	-	-	1.47	(1.29–1.68)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs						
1st child	-	-	-	1.42	(1.17–1.71)	<0.001
2nd or 3rd child, interval ≤2 yrs	-	-	-	1.48	(1.19–1.84)	<0.001

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4th or higher child, interval>2 yrs	-	-	-	1.10	(0.93─1.30)	0.288
4th or higher child, interval≤ 2 yrs	-	-	-	1.89	(1.58─2.26)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.24	(1.12─1.38)	<0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section˟	-	-	-	1.74	(1.25─2.42)	0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ˟Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for under-five mortality (age 0–59 months)

Multivariable analyses indicated significant associations with under-five mortality in those of a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.89, CI: 1.58–2.26); children of a second or third higher birth order with a short birth interval ≤2 years were also more likely to die (HR = 1.49, CI: 1.20–1.85). Additional associations included having a mother aged <20 years (HR = 1.47, CI: 1.27–1.71) and having a mother with no formal education (HR = 1.19, CI: 1.02–1.41). Children from poor households were about one and a half times as likely to die within 59 months of life as those from rich household (HR = 1.43, CI: 1.17–1.76). Other significant factors that influenced a child's under-five mortality included having a birth size that was perceived by the mother to be smaller than the average size (HR = 1.47, CI: 1.29–1.68); being of the male gender (HR = 1.24, CI: 1.12–1.38); having had a caesarean section delivery (HR = 1.74, CI: 1.25–2.42); and residing in rural rather than urban areas (HR = 1.29, CI: 1.11–1.50) (Table 3).

DISCUSSION

We found that over the past 10 years, there has been a steady decline in the rates of infant, post-neonatal, child, and under-five mortalities in Nigeria. While this trend shows that

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Nigeria is making progress, the pace of this progress still remains too slow to achieve the Millennium Development Goal of reducing Nigeria's child mortality to 76 deaths per 1,000 live births by the year 2015.

The findings from this present study show that child mortality risk factors were consistent across each of the four age ranges, and related to living in a poor household; living in a rural area; and having a mother with no schooling. Infant, post-neonatal and under-five deaths were also associated with having a younger mother (< 20 years); being perceived as a small or very small newborn by their mothers; and having a higher birth order with a birth interval ≤2 years. Previous delivery by caesarean section and being of the male gender were significantly associated with infant and under-five child mortality.

Our study's findings of greater mortality risk for children of all four age ranges living in poor households are similar to those reported in earlier reviews. Economic status has been reported as having a great impact on children, particularly those in the post-neonatal stage.[32-34] In Nigeria, more than two-thirds of the population live below the international poverty line of $1.25 per day.[35] Such poverty limits the opportunities for most mothers to access appropriate healthcare services for their children, resulting in a high probability of infant and child death.

Past studies have also shown that there are high risks of mortality amongst children aged less than 5 years whose mothers had no schooling.[33, 36-38] Our study also found that children of mothers with no schooling are at a greater risk of death across all four age groups compared with those whose mothers had a secondary or higher level of education. Educated mothers are more likely to have better knowledge about child health and modern healthcare services, and is a key determinant of poor child health.[39] Improved maternal healthcare-seeking behaviours [40, 41], such as immunisation and feeding practices, may in turn

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positively influence child survival. Educated mothers are additionally more likely to reside in socially and economically developed areas that have well-equipped medical facilities and good water and sanitation infrastructure.[42]

The current study found that children aged under 5 years born to mothers living in rural areas had a higher mortality risk compared with those living in urban areas. This finding is consistent with mortality study conducted in Bangladesh [36], Burkina Faso [43], and Rwanda.[44] The significantly higher risk of death among children who live in rural areas in Nigeria noted in the present study may be attributed to limited access to healthcare facilities, poor educational and transport services, unavailability of a safe water supply and inadequate basic sanitation facilities. Such conditions disproportionally hinder rural dwellers from receiving adequate healthcare and social and economic services, which adversely affect child survival.[45]

Children born to mothers younger than 20 years of age were at a greater risk of infant, post-neonatal, and under-five mortality. Factors contributing to this finding could include physical immaturity, pregnancy complications, poor nutritional status, inadequate use of maternal health services, and inexperience in child rearing among younger mothers.[46]

The risks of infant and under-five mortalities were significantly higher for male children than for female children; post-neonatal and child mortalities did not significant differ by gender in the multivariable analyses. Biological factors [47-49] may be possible explanations to the increased risk of male deaths. The high rate of infant and under-five deaths among males may be due to late development of fetal lung maturity in the first week of life [50], resulting in a higher incidence of respiratory diseases in male individuals compared with female individuals.

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Findings from this study indicate that children of fourth or higher birth order born with shorter birth intervals (≤2 years) were at a greater risk of dying at infant, post-neonatal, and under-five ages. This result is consistent with previous studies conducted in India and Kenya, [51-53] and may reflect that short-interval births may adversely affect a maternal health and wellbeing, economic resource competition among infants, particularly in poorer households.[51] We also found that the risk of infant, post-neonatal, and under-five mortality was significantly higher for children whose mother perceived their size to be small or very small after birth compared with those who were perceived as average or larger size. This observation may be explained by the influence of biologically associated risk factors such as low birth weight, poor nutritional status and prematurity.[54, 55]

A higher likelihood of infant and under-five deaths was associated with mothers who delivered by caesarean section compared with vaginal deliveries. This finding is not in agreement with study conducted in Sao Paulo, Brazil, which indicated a statistically insignificant relationship between caesarean delivery and infant mortality.[56] Additionally, a cross-sectional study conducted in India in 2012 also reported an insignificant relationship between under-five mortality and caesarean delivery.[23] The possible explanation for the high risk associated with caesarean section in our current study may be attributed to negative perceptions, such as misconception, fear, and aversion to caesarean section among mothers in Nigeria.[57, 58] This could explain why pregnant mothers are presented to health facilities after experiencing labor at home or elsewhere, with life threatening complications for emergency caesarean section.[59]

CONCLUSION

This study found that under-five mortality has declined significantly by 37% over a 10-year period after adjusting for individual, household and community level factors. Our findings

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indicated that living in poor households, living in rural areas and having mothers with no schooling are common significant risk factors for mortality across all four age ranges (infant, post-neonatal, child and under-five) in Nigeria. Community-based interventions that target mothers living in rural areas and mothers with low socioeconomic status are needed for improving child survival in Nigeria.

Contributors

Osita K. Ezeh and Kingsley E. Agho were involved in the conception and design of this study. Osita conducted the literature review, carried out the analysis and drafted the manuscript. Kingsley Agho, Michael J. Dibley, John J Hall and Andrew N Page provided advice on interpretation and revised and edited the manuscript. All authors read and approved the manuscript.

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Ethics approval

This study was based on an analysis of existing public domain survey datasets that is freely available online with all identifier information removed. The first author communicated with MEASURE DHS/ ICF International and permission was granted to download and use the data for his doctoral dissertation with the School of Medicine at the University of Western Sydney, Australia.

Data sharing statement No additional data are available

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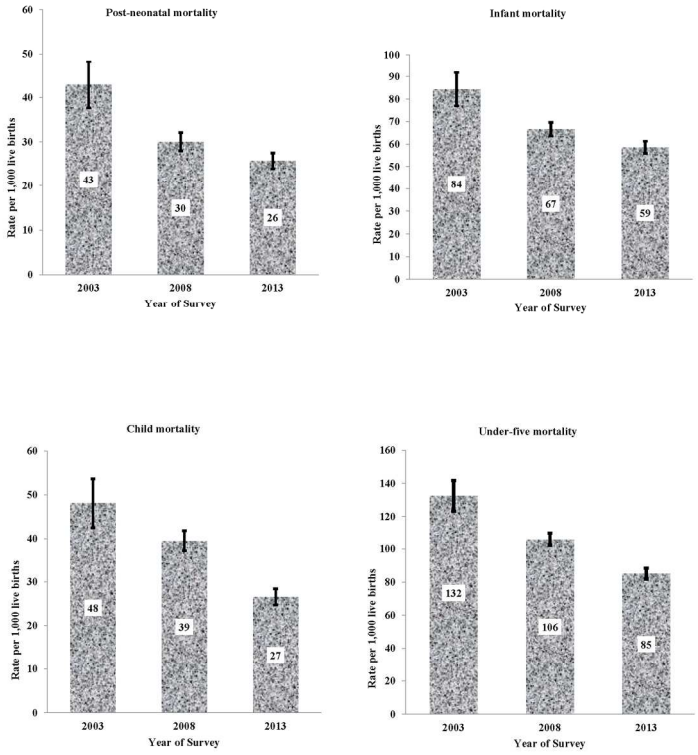
Figure 1. Post-neonatal, infant, child and under-five deaths per 1,000 live-births (singleton), with 95% confidence interval by year of NDHS survey, 2003–2013.



173x233mm (300 x 300 DPI)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Risk factors for post-neonatal, infant, child, and under-five mortality in Nigeria: A pooled cross-sectional analysis

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Risk factors for post-neonatal, infant, child, and under-five mortality in Nigeria: A pooled cross-sectional analysis

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Keywords: mortality, post-neonatal, infant, child, under-five, Nigeria

Word Count: 3,117

ABSTRACT

Objectives: To identify common factors associated with post-neonatal, infant, child, and under-five mortality in Nigeria.

Design, setting and participants: A cross sectional data of three Nigeria Demographic and Health Surveys (NDHS) for the years 2003, 2008 and 2013 were used. A multi-stage, stratified, cluster random sampling method was used to gather information on 63,844 singleton live-born infants of the most recent birth of a mother within a 5-year period before each survey was examined using cox regression models.

Main outcome measures: Post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and under-five mortality (death between birth and 59 months).

Results

Multivariable analyses indicated that children born to mothers with no formal education was significantly associated with mortality across all four age ranges (Adjusted hazard ratios (HR) =1.30, 95% confidence interval (CI): 1.01– 1.66 for post-neonatal, HR= 1.38, 95% CI: 1.11– 1.84 for infant, HR= 2.13, 95% CI: 1.56– 2.89 for child, and HR= 1.19, 95% CI: 1.02– 1.41 for under-five). Other significant factors included living in rural areas (HR= 1.48, 95% CI: 1.16– 1.89 for post-neonatal, HR= 1.23, 95% CI: 1.03– 1.47 for infant, HR= 1.52, 95% CI: 1.16– 1.99 for child, and HR= 1.29, 95% CI: 1.11– 1.50 for under-five), and poor household

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(HR= 2.47, 95% CI: 1.76– 3.47 for post-neonatal, HR= 1.40, 95% CI: 1.10– 1.78 for infant, HR= 1.72, 95% CI: 1.19– 2.49 for child, and HR= 1.43, 95% CI: 1.17– 1.76 for under-five).

Conclusion

This study found that no formal education, poor households and living in rural areas increased the risk of post-neonatal, infant, child and under-five mortality among Nigerian children. Community-based interventions for reducing under-five deaths are needed and should target children born to mothers of low socioeconomic status.

Strengths and limitations of this study

- This study is based on nationally representative household surveys that reflect every locality in Nigeria.
- Data were pooled together to create large sample sizes of deaths reported within 5 years preceding the surveys.
- Analyses were restricted to births within 5 years of each of the surveys to reduce recall bias by mothers interviewed and to minimise bias that may have arisen from changes in household characteristics.
- Newborn dates of birth and death given by mothers may have been misreported—particularly those that had occurred a few months or years before the survey.
- Causes of death and medical conditions of children were unknown at the time of survey.

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INTRODUCTION

Globally, the mortality rate of children aged under 5 years has reduced from 90 deaths per 1,000 live births in 1990 to 48 deaths in 2012; but the rate still remains very high in sub-Saharan Africa (from 177 to 98 deaths). In 2012, approximately half the world's estimated 6.6 million deaths in children aged less than 5 years occurred in sub-Saharan Africa, and Nigeria accounted for approximately 13% of these deaths.[1] The majority of these deaths are caused by communicable diseases such as malaria, diarrhoea, measles, cholera and respiratory infections. While these deaths are both preventable and treatable, the lack of effective health intervention policies has resulted in a high under-five child mortality rate in the region.

Childhood mortality remains a major public health challenge in Nigeria, despite substantial global decline in childhood deaths. Currently, the country has the highest reported number of under-five deaths in Africa and ranks as having the second highest number (after India) worldwide. Nearly one million children aged under 5 years die in Nigeria annually, and more than 60% of these deaths occur between 1 and 59 months of life.[1] Evidence from the Nigeria Demographic and Health Surveys (NDHS) showed that over a 10-year period (from 2003 to 2013), infant mortality rates (IMR) fell by 31% (from 100 to 69 deaths per 1,000 births); post-neonatal mortality rates (PMR) dropped by approximately 40% (from 52 to 31 deaths); and child mortality rates (CMR) declined by approximately 43% (from 112 to 64 deaths). Similarly, under-five child mortality rates (U5MR) decreased by approximately 36% (from 201 to 128 deaths).[2, 3] The current U5MR of 128 deaths per 1,000 live births reported by the NDHS implies that approximately one in every eight children aged under 5 years in Nigeria dies before having a fifth birthday—approximately 21 times the average rate for developed countries (6 deaths per 1000 live births).[1] With this marginal reduction in

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childhood deaths, it is more likely that Nigeria will not achieve the Millennium Development Goal target of 76 deaths per 1,000 live births by 2015.

Previous studies on childhood mortality in Nigeria have included multiple births in their analyses by primarily using one single data set to examine factors associated with under-five child mortality.[4-10] However, these studies have limited generalizability, in part, because of the limited number of deaths recorded in any single NDHS. Other studies have also found that including multiple births in the analysis of factors associated with under-five child mortality may produce inaccurate mortality risk estimates compared with using only singleton births in the analysis.[11-18]

Inadequate health facilities, insufficient skilled health professionals, and lack of modern medical equipment have undermined the Nigerian healthcare system, particularly in rural areas.[19] As a result, the Nigerian government launched and implemented National Health Policy (NHP) and Ward Health System (WHS) whose core targets include reduction of under-five mortality rate.[3] Despite all these initiatives, deaths of children < 5 years of age still remain high in Nigeria. Hence, this present study aimed to identify common factors that affect childhood mortality in Nigeria in different age ranges of the first 59 months of life (infant, 0–11 months; post-neonatal, 1–11 months; child, 12–59 months; and under-five, 0–59 months). Using pooled data may provide an important framework for public health researchers and policy makers in reviewing and designing new child survival intervention strategies.[20]

METHODS

The data sets used in this study were the 2003, 2008, and 2013 NDHS surveys, pooled together to maximise the sample sizes of deaths. Information on births and deaths of children

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aged younger than 5 years was obtained from 79,953 eligible women aged 15–49 years who participated in the surveys.[2, 3, 21]

From these women, data on a (weighted) total of 66,154 live-born infants were obtained, including singleton and multiple births of the mothers' most recent birth within 5 years prior to the survey date. The number of live births included was 6,219 from the 2003 survey; 28,107 from the 2008 survey; and 31,828 from 2013 survey. A total of 2,310 multiple births were excluded in the final analyses. The analyses were restricted to live births and most recent births during the 5 years preceding the surveys to limit mothers' potential for differential recall of events, as deliveries had occurred at different points in time prior to the interview. Detailed sampling methods used in gathering the data have been reported elsewhere.[2, 3, 21]

Study outcome variables

The main outcome variables in the study were post-neonatal mortality (death between 1 month and 11 months), infant mortality (death between birth and 11 months), child mortality (death between 12 and 59 months) and total under-five mortality (death between birth and 59 months). Each death case was coded as 1, and each non-death (alive) case was coded as 0.

Study factors

Study factors for this study were based on the Mosley and Chen framework of factors influencing child survival in developing countries;[22] other previous studies [23-29] on childhood mortality (particularly in the sub-Saharan Africa region) also played a role in the assessment of potential study variables. These variables were adapted to the data available in the merged dataset and comprised geographic location of place of residence (categorised as

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urban-rural residence), a household measure of income and a range of individual level factors.

Individual-level factors consisted of maternal characteristics (religion, education, literacy level, age, body mass index, occupation and desire for pregnancy); child characteristics (sex, birth place, size, mode of delivery, delivery assistance, and a combination of birth order and birth interval); and paternal education.

The only household level factor used was the wealth index variable, which measured the economic status of the households interviewed in the survey. A principal components analysis (PCA) was used in constructing the wealth index.[30] Weights were assigned to the household facilities and assets of respondents. The facilities and assets included were those that were consistent across the pooled NDHS data: television, radio, refrigerator, car, bicycle, motorcycle, source of drinking water, type of toilet facility, electricity and type of building materials used in the place of dwelling. In the NDHS data set, the household wealth index was categorised into five quintiles: poorest, poorer, middle, richer and richest. However, in the analysis, the household wealth index was re-categorised into three groups: the bottom 40% of households were referred to as poor households, the next 40% as middle households and the top 20% as rich households.

Statistical analysis

First, an estimation of mortality rates for singleton live births in each of the measured age ranges was conducted according to the year of survey, using a method similar to that described by Rutstien and Rojas.[31] This step was followed by a multivariable analysis that independently assessed the effect of each factor for each of the study outcome variables after adjusting for potential confounding variables; Cox proportional hazard regression models were used in this assessment.

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The multivariable analysis model for each of the study outcomes performed used a stepwise backwards elimination process to identify independent variables that were significantly associated with the study outcomes. To reduce any statistical error in our analyses, we double checked our backward elimination method by using the following procedures: (1) we entered only potential risk factors with a p value < 0.20 obtained in the univariable analysis for backward elimination process, (2) we tested the backward elimination by including all of the variables (all potential confounding factors), and (3) we tested and reported any collinearity in the final model.

The hazard ratios (HR) and their 95% confidence intervals (CIs) obtained from the adjusted Cox proportional models were used to measure the effect of predictor variables with the study outcomes (infant, post-neonatal, child, and under-five deaths). All statistical analyses were conducted using "SVY" commands in STATA/MP version 12.0 (StataCorp, College Station, TX, USA) to adjust for the cluster sampling survey design, weights, and standard errors.

RESULTS

A weighted total of 6,285 deaths of children aged under 5 years occurred within the 5-year period preceding the survey interview dates: 1,859 between 1 month and 11 months (post-neonatal mortality); 4,113 occurred between birth and 11 months (infant mortality); and 2,172 between 12 and 59 months (child mortality). The distribution of 6,285 children who died before their fifth birthday according to community, individual and household level characteristics are presented in Table 1. In the pooled NDHS data, more than 74% of the post-neonatal, infant, child and under-five deaths occurred in the rural areas. Delivery assisted by non-health professionals had the highest percent of deaths compared with health professionals (56.4% post-neonatal, 51.2% infant, 65.6% child, and 56.1% under-five).

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Table 1. Distribution of post-neonatal, infant, child and under-five mortality, reported in three demographic and health surveys in Nigeria, 2003 – 2013 (N=6,285).

Variables	Post-neonatal n (%)	Infant n (%)	Child n (%)	Under-five n (%)
Community level factors				
Residence type				
Urban	444 (23.9)	1042 (25.3)	379 (17.4)	1421 (22.6)
Rural	1416 (76.1)	3071 (74.7)	1793(82.6)	4864 (77.4)
Geopolitical zone				
North Central	250 (13.5)	521 (12.7)	211 (9.7)	732 (11.6)
North East	377 (20.3)	806 (19.6)	486 (22.4)	1291 (20.5)
North West	721 (38.8)	1530 (37.2)	1052(48.5)	2583 (41.1)
South East	193 (10.4)	405 (9.9)	135 (6.2)	540 (8.6)
South West	174 (9.4)	438 (10.6)	169 (7.8)	607 (9.7)
South South	143 (7.7)	413 (10.0)	119 (5.5)	533 (8.5)
Household wealth index				
Poor	845 (45.4)	1784 (43.4)	1088(50.1)	2872 (45.7)
Middle	760 (40.9)	1658 (40.3)	867 (39.9)	2525 (40.2)
Rich	254 (13.7)	671 (16.3)	218 (10.0)	889 (14.1)
Individual related factors				
Mother's religion[x]				
Traditionalist and other	190 (10.3)	366 (9.0)	252 (11.6)	618 (9.9)
Islam	1030 (55.7)	2226 (54.4)	1410(65.0)	3636 (58.1)
Catholic and other Christian	618 (33.4)	1472 (36.0)	495 (22.8)	1966 (31.4)
Mother's age at birth				
< 20	125 (6.7)	322 (7.8)	91 (4.2)	413 (6.6)
20-29	886 (47.7)	1929 (46.9)	1023(47.1)	2952 (47.0)
30-39	641 (34.5)	1394 (33.9)	780 (35.9)	2174 (34.6)
40-49	206 (11.1)	468 (11.4)	278 (12.8)	746 (11.9)
Mother's education				
No education	1078 (58.0)	2213 (53.8)	1435(66.1)	3648 (58.0)
Primary	382 (20.5)	917 (22.3)	432 (19.9)	1350 (21.5)
Secondary or higher	399 (21.5)	983 (23.9)	305 (14.0)	1287 (20.5)
Mother's literacy level[x]				
Cannot read at all	1312 (70.6)	2755 (67.0)	1691(77.9)	4446 (70.7)
Able to read	542 (29.1)	1330 (32.3)	465 (21.4)	1795 (28.6)
Mother's desire for pregnancy[x]				
Wanted then	1611 (86.6)	3541 (86.1)	1909(87.9)	5450 (86.7)
Wanted later	112 (6.1)	234 (5.7)	107 (4.9)	341 (5.4)
Wanted no more	53 (2.9)	124 (3.02)	48 (2.2)	172 (2.7)
Mother's body mass index[x]				
Greater than 18.5	1621 (87.2)	3634 (88.3)	1892(87.1)	5526 (87.9)
Less than or equal to 18.5	201 (10.8)	408 (9.9)	241 (11.1)	650 (10.3)
Mother's working status[x]				
Not working	632 (35.2)	1402 (35.4)	784 (37.2)	2186 (36.0)

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Working	1158 (64.5)	2548 (64.3)	1320(62.6)	3867 (63.7)
Father's education[¤]				
No education	865 (46.5)	1762 (42.8)	1151(53.0)	2913 (46.4)
Primary	388 (20.9)	867 (21.1)	450 (20.7)	1316 (20.9)
Secondary or higher	552 (29.7)	1360 (33.1)	509 (23.5)	1869 (29.7)
Sex of child				
Female	887 (47.7)	1838 (44.7)	1057(48.7)	2895 (46.1)
Male	973 (52.3)	2275 (55.3)	1115(51.3)	3390 (53.9)
Mother's perceived baby size[¤]				
Small or very small	301 (16.2)	795 (19.3)	352 (16.2)	1148 (18.3)
Average or larger	1446 (77.8)	3006 (73.1)	1702(78.4)	4708 (74.9)
Birth order and birth interval				
First child	347 (18.7)	947 (23.0)	370 (17.0)	1317 (21)
2 or 3 child, interval > 2	337 (18.1)	699 (17.0)	398 (18.3)	1098 (17.5)
2 or 3 child, interval <= 2	229 (12.3)	497 (12.1)	218 (10.0)	715 (11.4)
4 or more child, interval > 2	542 (29.1)	1114 (27.1)	700 (32.2)	1814 (28.9)
4 or more child, interval <= 2	404 (21.7)	856 (20.8)	486 (22.4)	1341 (21.3)
Mode of delivery[¤]				
Non-caesarean	1831 (98.5)	3978 (96.7)	2149(98.9)	6127 (97.5)
Caesarean section	17 (0.9)	103 (2.5)	13 (0.6)	115 (1.8)
Delivery assistance[¤]				
Health professional	493 (26.5)	1307 (31.8)	411 (18.9)	1718 (27.3)
non-Health professional	1049 (56.4)	2104 (51.2)	1424(65.6)	3528 (56.1)
Birth place of child[¤]				
Health facility	271 (25.3)	1239 (30.1)	386 (17.8)	1625 (25.9)
Home	1307 (70.3)	2673 (65.0)	1693(78.0)	4367 (69.5)

N, Weighted total; [¤]Percentages did not add up to 100% because of missing values; n (%), frequency (and proportion dead) across variables.

Between 2003 and 2013, IMR for singleton live born infants decreased by approximately 30%, from 84 deaths per 1000 live births in 2003 to 59 in 2013; PMR fell by approximately 40%, from 43 to 26 deaths; CMR declined by 44%, from 48 to 27 deaths; and U5MR dropped by 36%, from 132 to 85 deaths (Figure 1).

[Figure 1 here]

Risk factors for post-neonatal mortality (1-11 months)

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Post-neonates born to younger mothers (age <20 years) reported a significantly higher risk of post-neonatal deaths (HR = 3.45, CI: 2.19–5.46) compared to those born to mothers aged between 30 and 39 years. Post-neonates living in rural areas were also more likely to die (HR = 1.48, CI: 1.16–1.89) than those living in urban areas. When place of residence was replaced by household wealth index in the final model, there was a significantly higher risk of post-neonatal death for those born to mothers from poor households (HR = 2.47, CI: 1.76–3.47) and middle-class households (HR = 1.93, CI: 1.40–2.67) compared to wealthy households. Other factors that were significantly associated with post-neonatal deaths included having a mother with no formal education (HR = 1.30, CI: 1.01–1.66); having a birth size that was perceived as small or smaller (HR = 1.44, CI: 1.14–1.81); and having a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.92, CI: 1.40–2.64) (Table 2).

Table 2. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with post-neonatal and infant mortality

Variables	Post-neonatal (1-11 months)			Infant (0-11 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.70	(0.53–0.93)	0.014	0.80	(0.64–0.99)	0.038
2013	0.52	(0.38–0.71)	<0.001	0.66	(0.53–0.83)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.48	(1.16–1.89)	0.002	1.23	(1.03–1.47)	0.023
Household wealth index						
Rich				1.00		
Middle	-	-	-	1.37	(1.11–1.69)	0.003
Poor	-	-	-	1.40	(1.10–1.78)	0.006
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.13	(0.86–1.48)	0.388	1.01	(0.95–1.39)	0.418
No education	1.30	(1.01–1.66)	0.044	1.38	(1.11–1.84)	0.039
Mother's age						
30 - 39 years	1.00			1.00		
Less than 20 years	3.45	(2.19–5.46)	<0.001	3.04	(2.28–4.05)	<0.001
20 - 29 years	1.59	(1.23–2.04)	<0.001	1.31	(1.12–1.54)	0.001
40 - 49 years	1.08	(0.82–1.42)	0.578	1.09	(0.90–1.31)	0.385

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Mother's perceived baby size						
Average or large	1.00			1.00		
Small or very small	1.44	(1.14–1.81)	0.002	1.74	(1.50–2.02)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs	1.00					
1st child	1.13	(0.80–1.61)	0.488	1.38	(1.10–1.72)	0.005
2nd or 3rd child, interval ≤2 yrs	1.64	(1.13–2.37)	0.009	1.52	(1.18–1.97)	0.001
4th or higher child, interval>2 yrs	1.39	(1.05–1.85)	0.024	1.30	(1.06–1.60)	0.014
4th or higher child, interval≤ 2 yrs	1.92	(1.40–2.64)	<0.001	1.94	(1.56–2.41)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.23	(1.09–1.39)	0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section×	-	-	-	1.74	(1.24–2.45)	<0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ×Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for infant mortality (0-11 months)

Infants born to mothers from poor households (HR = 1.40, CI: 1.10–1.78) and middle-class households (HR = 1.37, CI: 1.11–1.69) had a higher risk of infant mortality than wealthy households. Infants whose birth size was perceived as small or smaller had a 1.74 times greater risk of dying than those perceived as average or larger in size. Male infants were also more likely to die (HR = 1.23, CI: 1.09–1.39) than female infants, as were infants living in rural areas (HR = 1.23, CI: 1.03–1.47). Other significant factors that affected infant mortality included infants born to mothers <20 years old (HR = 3.04, CI: 2.28–4.05); infants of fourth or higher birth order with a birth interval ≤ 2 years (HR = 1.94, CI: 1.56–2.41); infants of illiterate mothers (HR = 1.38, CI: 1.11–1.84); and infants whose deliveries occurred by Caesarean section (HR = 1.74, CI: 1.24–2.45) (Table 2).

Risk factors for child mortality (age 12–59 months)

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Children aged between 12 and 59 months had a significantly higher risk of child mortality if their mothers had either no formal education (HR = 2.13, CI: 1.56–2.89) or else had only a primary education (HR = 1.58, CI: 1.13–2.20). Similar findings were observed when we replaced maternal education with paternal education in the final model; children whose fathers had no formal education were more likely to die (HR = 1.73, CI: 1.34–2.22). Children from poor households were also more likely to die (HR = 1.72, CI: 1.19–2.49), as were children whose mothers resided in rural areas (HR = 1.52, CI: 1.16–1.99) (Table 3).

Table 3. Adjusted hazard ratio (95% confidence interval) for variables significantly associated with child and under-five mortality

Variables	Child (12-59 months)			Under-5 (0-59 months)		
	HR^*	[95%CI]	*P*	HR^*	[95%CI]	*P*
Year of survey						
2003	1.00			1.00		
2008	0.71	(0.54–0.93)	0.015	0.75	(0.63–0.90)	0.002
2013	0.50	(0.38–0.68)	<0.001	0.63	(0.52–0.76)	<0.001
Residence type						
Urban	1.00			1.00		
Rural	1.52	(1.16–1.99)	0.002	1.29	(1.11–1.50)	0.001
Household wealth index						
Rich	1.00			1.00		
Middle	1.63	(1.14–2.32)	0.007	1.42	(1.18–1.70)	0.001
Poor	1.72	(1.19–2.49)	0.004	1.43	(1.17–1.76)	0.001
Individual level factors						
Mother's education						
Secondary or higher	1.00			1.00		
Primary	1.58	(1.13–2.20)	0.007	1.11	(0.93–1.32)	0.244
No education	2.13	(1.56–2.89)	<0.001	1.19	(1.02–1.41)	0.032
Mother's age						
30 - 39 years				1.00		
Less than 20 years	-	-	-	1.44	(1.13–1.85)	0.004
20 - 29 years	-	-	-	1.04	(0.92–1.19)	0.519
40 - 49 years	-	-	-	1.47	(1.27–1.71)	<0.001
Mother's perceived baby size						
Average or large				1.00		
Small or very small	-	-	-	1.47	(1.29–1.68)	<0.001
Birth order and birth interval						
2nd or 3rd child, interval>2 yrs						
1st child	-	-	-	1.42	(1.17–1.71)	<0.001
2nd or 3rd child, interval ≤2 yrs	-	-	-	1.48	(1.19–1.84)	<0.001

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4th or higher child, interval>2 yrs	-	-	-	1.10	(0.93─1.30)	0.288
4th or higher child, interval≤ 2 yrs	-	-	-	1.89	(1.58─2.26)	<0.001
Sex of child						
Female	-	-	-	1.00		
Male	-	-	-	1.24	(1.12─1.38)	<0.001
Mode of delivery						
Non-caesarean	-	-	-	1.00		
Caesarean section˟	-	-	-	1.74	(1.25─2.42)	0.001

^Independent variables adjusted for: place of residence, wealth index, mother's (religion, education, age, body mass index (BMI), work status and desire for pregnancy), father's education, child's (sex, birth place, body size, mode of delivery, delivery assistance, birth order and birth interval); *multiple births were excluded from the analysis; HR, hazard ratio; CI, confidence interval; p-values based on Cox regression; ˟Caesarean section is a combination of both elective and emergency caesarean; - variables that were not statistically significant; yrs, years.

Risk factors for under-five mortality (age 0–59 months)

Multivariable analyses indicated significant associations with under-five mortality in those of a fourth or higher birth order with a short birth interval ≤2 years (HR = 1.89, CI: 1.58–2.26); children of a second or third higher birth order with a short birth interval ≤2 years were also more likely to die (HR = 1.49, CI: 1.20–1.85). Additional associations included having a mother aged <20 years (HR = 1.47, CI: 1.27–1.71) and having a mother with no formal education (HR = 1.19, CI: 1.02–1.41). Children from poor households were about one and a half times as likely to die within 59 months of life as those from rich household (HR = 1.43, CI: 1.17–1.76). Other significant factors that influenced a child's under-five mortality included having a birth size that was perceived by the mother to be smaller than the average size (HR = 1.47, CI: 1.29–1.68); being of the male gender (HR = 1.24, CI: 1.12–1.38); having had a caesarean section delivery (HR = 1.74, CI: 1.25–2.42); and residing in rural rather than urban areas (HR = 1.29, CI: 1.11–1.50) (Table 3).

DISCUSSION

We found that over the past 10 years, there has been a steady decline in the rates of infant, post-neonatal, child, and under-five mortalities in Nigeria. While this trend shows that

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Nigeria is making progress, the pace of this progress still remains too slow to achieve the Millennium Development Goal of reducing Nigeria's child mortality to 76 deaths per 1,000 live births by the year 2015.

The findings from this present study show that child mortality risk factors were consistent across each of the four age ranges, and related to living in a poor household; living in a rural area; and having a mother with no schooling. Infant, post-neonatal and under-five deaths were also associated with having a younger mother (< 20 years); being perceived as a small or very small newborn by their mothers; and having a higher birth order with a birth interval ≤2 years. Previous delivery by caesarean section and being of the male gender were significantly associated with infant and under-five child mortality.

Our study's findings of greater mortality risk for children of all four age ranges living in poor households are similar to those reported in earlier reviews. Economic status has been reported as having a great impact on children, particularly those in the post-neonatal stage.[32-34] In Nigeria, more than two-thirds of the population live below the international poverty line of $1.25 per day.[35] Such poverty limits the opportunities for most mothers to access appropriate healthcare services for their children, resulting in a high probability of infant and child death.

Past studies have also shown that there are high risks of mortality amongst children aged less than 5 years whose mothers had no schooling.[33, 36-38] Our study also found that children of mothers with no schooling are at a greater risk of death across all four age groups compared with those whose mothers had a secondary or higher level of education. Educated mothers are more likely to have better knowledge about child health and modern healthcare services, and is a key determinant of poor child health.[39] Improved maternal healthcare-seeking behaviours [40, 41], such as immunisation and feeding practices, may in turn

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positively influence child survival. Educated mothers are additionally more likely to reside in socially and economically developed areas that have well-equipped medical facilities and good water and sanitation infrastructure.[42]

The current study found that children aged under 5 years born to mothers living in rural areas had a higher mortality risk compared with those living in urban areas. This finding is consistent with mortality study conducted in Bangladesh [36], Burkina Faso [43], and Rwanda.[44] The significantly higher risk of death among children who live in rural areas in Nigeria noted in the present study may be attributed to limited access to healthcare facilities, poor educational and transport services, unavailability of a safe water supply and inadequate basic sanitation facilities. Such conditions disproportionally hinder rural dwellers from receiving adequate healthcare and social and economic services, which adversely affect child survival.[45]

Children born to mothers younger than 20 years of age were at a greater risk of infant, post-neonatal, and under-five mortality. Factors contributing to this finding could include physical immaturity, pregnancy complications, poor nutritional status, inadequate use of maternal health services, and inexperience in child rearing among younger mothers.[46]

The risks of infant and under-five mortalities were significantly higher for male children than for female children; post-neonatal and child mortalities did not significant differ by gender in the multivariable analyses. Biological factors [47-49] may be possible explanations to the increased risk of male deaths. The high rate of infant and under-five deaths among males may be due to late development of fetal lung maturity in the first week of life [50], resulting in a higher incidence of respiratory diseases in male individuals compared with female individuals.

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Findings from this study indicate that children of fourth or higher birth order born with shorter birth intervals (≤2 years) were at a greater risk of dying at infant, post-neonatal, and under-five ages. This result is consistent with previous studies conducted in India and Kenya, [51-53] and may reflect that short-interval births may adversely affect a maternal health and wellbeing, economic resource competition among infants, particularly in poorer households.[51] We also found that the risk of infant, post-neonatal, and under-five mortality was significantly higher for children whose mother perceived their size to be small or very small after birth compared with those who were perceived as average or larger size. This observation may be explained by the influence of biologically associated risk factors such as low birth weight, poor nutritional status and prematurity.[54, 55]

A higher likelihood of infant and under-five deaths was associated with mothers who delivered by caesarean section compared with vaginal deliveries. This finding is not in agreement with study conducted in Sao Paulo, Brazil, which indicated a statistically insignificant relationship between caesarean delivery and infant mortality.[56] Additionally, a cross-sectional study conducted in India in 2012 also reported an insignificant relationship between under-five mortality and caesarean delivery.[23] The possible explanation for the high risk associated with caesarean section in our current study may be attributed to negative perceptions, such as misconception, fear, and aversion to caesarean section among mothers in Nigeria.[57, 58] This could explain why pregnant mothers are presented to health facilities after experiencing labor at home or elsewhere, with life threatening complications for emergency caesarean section.[59]

Limitations

Some limitations that need to be considered when interpreting the results of this study include: (a) the cross sectional design limits any conclusions about causality of the factors we have examined; (b) the antecedent health and nutritional status history of children under 5

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years old, especially for those children who had died, and causes of death were lacking in the NDHS surveys, (c) this study did not adjust for effect of small-scale geographical inequality as demonstrated by previous studies.[44, 60] However, this study adjusted for intra-cluster correlation which is an appropriate statistical method for examining mortality from complex cluster sample survey data.[61]

CONCLUSION

This study found that under-five mortality has declined significantly by 37% over a 10-year period after adjusting for individual, household and community level factors. Our findings indicated that living in poor households, living in rural areas and having mothers with no schooling are common significant risk factors for mortality across all four age ranges (infant, post-neonatal, child and under-five) in Nigeria. Community-based interventions that target mothers living in rural areas and mothers with low socioeconomic status are needed for improving child survival in Nigeria.

Contributors

Osita K. Ezeh and Kingsley E. Agho were involved in the conception and design of this study. Osita conducted the literature review, carried out the analysis and drafted the manuscript. Kingsley Agho, Michael J. Dibley, John J Hall and Andrew N Page provided advice on interpretation and revised and edited the manuscript. All authors read and approved the manuscript.

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This study was based on an analysis of existing public domain survey datasets that is freely available online with all identifier information removed. The first author communicated with MEASURE DHS/ ICF International and permission was granted to download and use the data for his doctoral dissertation with the School of Medicine at the University of Western Sydney, Australia.

Data sharing statement No additional data are available

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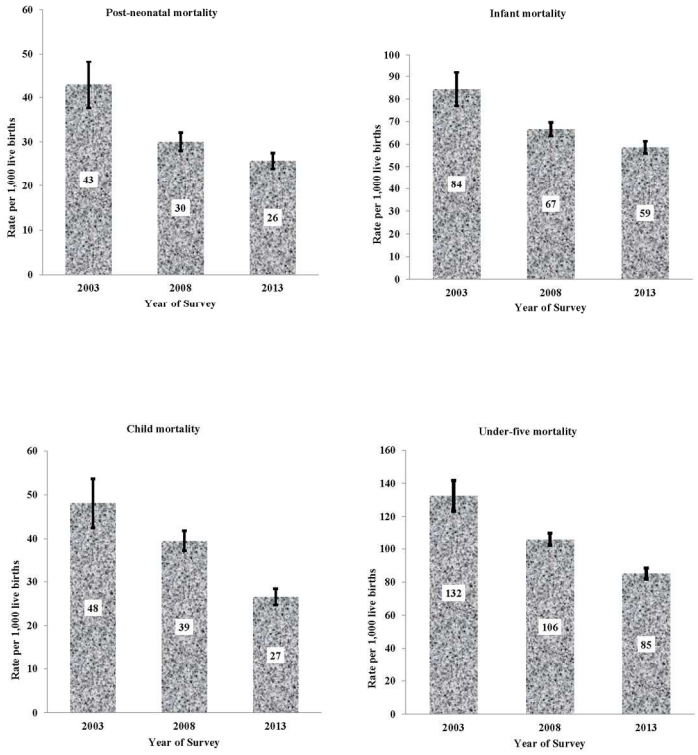
Figure 1. Post-neonatal, infant, child and under-five deaths per 1,000 live-births (singleton), with 95% confidence interval by year of NDHS survey, 2003–2013.



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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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