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Research Article

Prevalence and Factors Associated with under-5 Mortality in Nigeria: Evidence from 2018 Nigeria Demographic and Health Survey

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ABSTRACT

Under-five mortality is a substantial indicator of children's health, well-being, and consequently, socioeconomic development of a country. The primary focus of this study was to estimate the prevalence and identify the factors associated with under-5 mortality in Nigeria. This research utilized the most recent data from the Nigeria Demographic and Health Survey (NDHS 2018), which is a nationally representative survey. We included all children within 59 months from their birth. Cox proportional hazard (PH) and Cox frailty models were applied to identify the factors associated with under-5 child mortality. A total of 33,924 under-5 children were included. The prevalence of under-5 death was 9.5% [95% Confidence Interval (CI): 9.2–9.8]. In the Cox frailty model at community level, the model reported that multiple births [Hazard Ratio (HR) = 3.0; 95% CI: 2.7–3.4], male children (HR = 1.2; 95% CI: 1.1–1.2), and small-size babies at birth (HR = 1.4; 95% CI: 1.2–1.5) were strongly associated with the high risk of under-5 mortality. Parents with lower education, children from lower wealth quantities, and shorter childbirth intervals similarly had higher hazards of under-5 mortality for both the Cox PH and Cox frailty models. Our results suggest that different health strategies for improving education, nutrition, and family planning might contribute to reduce under-5 mortality in Nigeria. The Nigerian Federal Ministry of Health and other agencies should consider to scale up health interventions to reduce under-5 mortality.

1. INTRODUCTION

The paramount ill health of a community is often indicated by mortality [1]. Under-five mortality is considered a useful index for assessing a country's improvement in general medical and public health conditions. Globally, many low-and-middle income countries have been concerned about reducing mortality over the past four decades because its rise indicates a decline in living standards [2,3]. For a specific year if age-specific mortality is considered, the probability of death of a newborn child per thousand before its 5th birthday is termed as under-5 mortality [4]. During 1990–2016, under-5 mortality decreased from 93 to 41 deaths per 1000 live births, resulting in approximately 56% reduction in child mortality worldwide [5]. Moreover, the Sub-Saharan African region has proceeded to the worst improvement in reducing childhood mortality since 1990 [6].

Nigeria currently has the highest under-5 mortality rate (132 deaths for every 1000 live births) in Africa and globally ranked second highest [7]. In 2012, approximately 13% of Sub-Saharan child mortality occurred in Nigeria [8]. A summary of the 2018 Nigeria Demographic and Health Survey (NDHS) has been used to track the reported information [7]. The above statistics mark that under-5 death is still a significant health crisis in Nigeria.

Child mortality has a substantial impact on children's health and well-being and overall progress toward the Sustainable Development Goals (SDGs) [5]. UNICEF 2014 reported that more than 50 countries including Nigeria would probably miss the SDG goal on child mortality, and approximately 60 million under-5 children will die over the period 2017–2030 if the upward trend continues [9]. A previous study reported that children from the smaller birth interval and multiple births had higher odds of dying over the past 10 years in Ghana [10]. Mother's age, higher number of births, and region are linked with child mortality [11]. Besides, a Gini-type decomposition analysis reported that children's socioeconomic characteristics were the general contributor to the disparities in mortality among Sub-Saharan children [12]. A study in Nigeria found health-related, biodemographic, and socioeconomic factors associated with death among children within 5 years of life [13]. Uganda's children had higher childhood mortality hazards

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due to household head's gender, children's gender, and previous year's number of children [14]. Other studies found that women empowerment, family size, marital type, polygamy of fathers, and mothers' Nongovernmental Organization (NGO) membership are associated with under-5 mortality [15–18].

Nigeria was unsuccessful in attaining the target of Millennium Development Goal 4 as under-5 mortality is a complicated issue. Authors perceived the under-5 mortality trends have not fluctuated uniformly in Nigeria over the passage of time. Moreover, it substantially depends on various factors and obviously varies over time and location, and therefore needs to be studied on a regular basis. This study visualized the current scenario, related factors, and practical strategies to reduce Nigerian under-5 child mortality using the most recent and updated NDHS data.

Additionally, two different statistical techniques for the time-to-event dataset were adopted to detect the best-fitted model for acquiring precise estimates, nonexistent for Nigerian children.

The current study was designed to determine factors associated with childhood death before achieving their 5th birthday in Nigeria. Additionally, this research will help the government and NGOs formulate strategies to achieve SDG 3.2 for the Nigerian government.

2. MATERIALS AND METHODS

2.1. Data Source

This study analyzed data from the 2018 NDHS. Selection of sampling frames for conducting a survey is dependent on the 2006 Population and Housing Census of the Federal Republic of Nigeria (NPHC) [10]. The Primary Sampling Unit (PSU) of 2018 NDHS was the Enumeration Areas' (EAs) overall index. The sampling design was mentioned in the final report of 2018 NDHS [7]. The survey collected data through a stratified two-stage cluster sampling technique. It separated each state and the Federal Capital Territory into two broad sectors that were urban–rural localities. The first phase of sampling, 1400 EAs, was assigned with the sampling technique named probability proportional sampling, and it was proportionate to the EA shape. Here, a household recording procedure was performed, and the concluding list of households assisted as a skeleton of sampling in the second phase of selection. In the second phase, 30 households were determined for every EA with equal probability of systematic sampling. The survey curriculum movement started on August 14, 2018 and was completed on December 29, 2018.

Here, a total of 41,821 women aged 15–49 years participated in the interview. Mothers with children aged 0–59 months within 2015–2018 attended the survey to provide demographic and health information about children [7]. Overall, 33,924 children aged <5 years formed the study's analysis unit.

2.2 Response Variable

Under-five mortality refers to the death rate of children within their first 5 years. Here, the response was whether children were dead or not. The basic concept about time-to-event is that it combines the age and survival status (alive/death) of children. The age of each child (alive/dead) was recorded during the interview, and the age at death was reported. Children who survived at the age of 5 years counted as right censoring. Here, code one stood for dead cases and zero was for alive cases.

2.3. Independent Variables

The following socioeconomic and demographic factors of children and parents are expected to impact child mortality in Nigeria, selected based on the literature review [10–17]. Thirteen covariates were chosen for the analysis: maternal age (<20, 20–29, 30–39 or ≥40 years); maternal education (illiterate, completed primary, or secondary and higher); paternal education (illiterate, completed primary, or secondary and higher); maternal working status (no or yes); wealth status of the family (poor, middle or rich), sex of the child (male or female), maternal age at first birth (12–17, 18–30 or ≥30 years); number of living children (no living child or one or more living children); preceding birth interval (<24, 24–48 or >48 months); birth status (single or multiple births); child size at birth (average, small or large); place of residence (urban or rural); and place of delivery (home or hospital). Maternal age is considered a quantitative variable in the NDHS data set. The derivation of wealth status was from the wealth index. Principal component analysis was used to create the variable, and quintiles ranged from poorest to richest. The lower category (poor) was generated from merging poorest and poorer, whereas rich was created by combining richest and richer groups of study participants.

2.4. Missing Value Handling

The dataset had a small number of missing cases in explanatory variables. The missing cases were appended by variables, that is, husband education (6%), preceding birth interval (19%), and child size at birth (2%). The statistical model was run after discarding the missing case from independent variables. Finally, 25,141 children aged <5 years were prepared for multivariate analysis after excluding unnecessary and missing information.

2.5. Statistical Analysis

We used bivariate analysis to check the association between the response and the predictors. Rao–Scott χ^2 test was used to check the bivariate association between two covariates, testing the bivariate association's significance. Finally, the factors affecting under-5 mortality were determined using the Cox Proportional Hazard (PH) and Cox frailty models.

The useful method of identifying possible covariates effects on hazard function is a semiparametric method called the Cox PH model [19]. For the ith child, Y_i denotes the event or censoring time and the model indicator is C_i for,

$$C_i = \begin{cases} 1; & \text{when an event occurs} \\ 0; & \text{when an event does not occur} \end{cases}$$

The model has the following functional form [20]:

$$h\left(\frac{t}{X_i}\right) = h_0(t)e^{\left(\beta_1 X_{i1} + \beta_2 X_{i2} + \cdots\cdots + \beta_p X_{ip}\right)}$$

or,

$$h\left(\frac{t}{X_i}\right) = h_0(t)e^{\beta^T X_i}$$

Here, for ith child at time t, the vectors of the covariate are X_i and $\beta = (\beta_1 + \beta_2 + \cdots\cdots + \beta_p)^{\mathrm{T}}$ representing unknown regression parameters vector assuming equal for the children at time point t.

In this research, the risk of experiencing under-5 mortality is defined as the hazard function. Thus under-5 mortality is calculated from the probability of experiencing the demise of a child aged 0–59 months conditioned on the survival up to that time.

The Cox frailty model is the extended form of the standard Cox PH model. This model uses a multiplicative factor called the frailty factor (random effects) [19]. This model's basic assumption is that the frailty distribution form and its shape and structure of a hazard function contain the hidden internal or external factors information [20]. In mathematical notation, jth individual (children) belonging to the ith community or region called subgroup is presented as [21,22],

$$h_{ij}\left(\frac{t}{X_{ij}}, u_j\right) = U_j h_0(t)e^{\left(b^T X_{ij}\right)},\ i = 1(1)G, j = 1(1)n_i$$

An individual experiencing death at time t ($0 < t < 59$) (months) has the hazard $h_{ij}(t/X_{ij}, u_j)$. The baseline hazard function is defined by $h_0(t)$. The vector set of the explanatory variables (covariates) is denoted by X_{ij}, and the unknown regression parameters are β.

Therefore, the frailty term $U_j = e^u$ having a unit mean and Θ variance is independently and identically distributed for a given distribution. This term indicates dependency within a group. Moreover, with positive support, the term U_j follows different distributions. Gompertz, Gamma, Compound Poisson, lognormal, Positive Stable, Inverse Gaussian, and power variance function distribution are some of those distributions [22]. Gamma distribution is comparatively easy to implement among all other distributions, can fit failure data seemingly, and is one of the most popular ones [22]. Thus, for both the frailties (i.e., region and community), we used Gamma distribution.

To assess the frailty term's significance, the frailty effect's estimated variance (θ) was used. Heterogeneity was suspected when $\theta > 0$; it can be interpreted as the correlation of the likelihood of mortality in children belonging to similar communities/regions. If the estimated variance had zero magnitudes $\theta = 0$, child mortality was not different between communities/regions.

The current study adopted two frailty terms, which were community and region. Cluster number was considered a community variable and mentioned in the published report of 2018 NDHS [7]. These cluster numbers are called EAs, the PSU of the 2018 NDHS. According to the report of 2018 NDHS, there was 1400 EAs in the primary data set. EAs were deployed to find out an unobserved variation in child mortality. In Nigeria, the region was divided into six parts: south-west, south-south, south-east, north-west, north-east, and north-central. This was also used as a frailty term and had an unobserved effect on the study.

We used the Akaike Information Criterion (AIC) to select the dataset's best model. The model with the least amount of the mentioned criterion (AIC) for the Nigerian child mortality data was considered the best [23]. The sampling weight was applied in the analysis to make the findings nationally representative. All statistical analyses were conducted using Stata version 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP). Therefore, the complex sampling design was considered through Stata software using the command *svyset* for Cox models. The frailty model was delineated to deal with complex survey design.

2.6. Ethical Approval

The National Population Commission (Abuja, Nigeria) and Federal Ministry of Health jointly implemented the 2018 NDHS. The survey was conducted with human participants and followed Helsinki Declaration (1964) ethical standards [7]. As the data source was secondary, it was accessible from www.dhsprogram.com after DHS approval. The survey protocol was reviewed and approved by the National Health Ethics Committee of Nigeria and ICF International Review Board (FWA00000845, approval number: 132989.0.000.NG.DHS.01) [7]. An informed consent statement was provided to each parent/guardian before starting the interview to ensure the legally authorized participation and confidentiality of each child. We followed all the terms and conditions of the DHS program, and then the DHS program sent a confirmation in the format of an authorization letter. Therefore, we were eligible to utilize the dataset according to maintaining the signed confidentiality deed. More details regarding DHS data and ethical standards are available at http://goo.gl/ny8T6X.

3. RESULTS

3.1. Bivariate Analysis

Results from the bivariate analysis are shown in Table 1. Maternal age, maternal education, paternal education, wealth status of the family, maternal age at first birth, number of living children, preceding birth interval, birth status, child size at birth, place residence, and place of delivery were associated with under-5 child mortality in Nigeria.

3.2. Multivariate Analysis

In the multivariate analysis, community-level shared frailty had the smallest values of AIC (Table 2). Therefore, based on model selection criteria, the community-level shared frailty was the best-fitted model for NDHS (2018) under-5 child dataset. The model considered the Cox frailty model with community level, and there were 1400 communities in Nigeria. Among all considered covariates, unobserved heterogeneity of the death in the under-5 children in

Table 1 | Percentage distributions of child survival and mortality by selected covariates and Rao–Scott χ^2 test for determinates' association with under-5 mortality

Characteristics	Child survival status: Dead *n* (%)	Child survival status: Alive *n* (%)	*p*
Maternal age (years)			0.005
<20	148 (10.32)	1286 (89.68)	
20–29	1476 (9.17)	14,620 (90.83)	
30–39	1216 (9.29)	11,878 (90.71)	
≥40	371 (11.24)	2929 (88.76)	
Maternal education			<0.001
Illiterate	1864 (12.11)	13,527 (87.89)	
Completed primary	498 (9.44)	4776 (90.56)	
Secondary & higher	849 (6.40)	12,410 (93.60)	
Paternal education			<0.001
Illiterate	1472 (12.74)	10,079 (87.26)	
Completed primary	451 (9.73)	4186 (90.27)	
Secondary & higher	1074 (6.88)	14,528 (93.12)	
Maternal working status			0.059
No	1138 (10.26)	9949 (89.74)	
Yes	2073 (9.08)	20,764 (90.92)	
Wealth status of family			<0.001
Poor	1889 (11.95)	13,920 (88.05)	
Middle	662 (9.23)	6509 (90.77)	
Rich	660 (6.03)	10,284 (93.97)	
Sex of child			0.171
Male	1720 (9.97)	15,537 (90.03)	
Female	1491 (8.95)	15,176 (91.05)	
Maternal age at first birth (years)			<0.001
12–17	1484 (11.69)	11,209 (88.31)	
18–30	1678 (8.21)	18,764 (91.79)	
≥30	49 (6.21)	740 (93.79)	
Number of living children			<0.001
0	324 (100.00)	0 (0.00)	
≥1	2887 (8.59)	30,713 (91.41)	
Preceding birth interval (months)			<0.001
<24	944 (14.08)	5762 (85.92)	
24–48	1348 (8.33)	14,826 (91.67)	
>48	312 (6.93)	4190 (93.07)	
Birth status			<0.001
Single birth	2883 (8.83)	29,778 (91.17)	
Multiple births	328 (25.97)	935 (74.03)	
Child size at birth			<0.001
Average	1551 (8.84)	16,000 (91.16)	
Small	595 (13.01)	3977 (86.99)	
Large	982 (8.71)	10,293 (91.29)	
Place of residence			<0.001
Urban	848 (7.25)	10,851 (92.75)	
Rural	2363 (10.63)	19,862 (89.37)	
Place of delivery			<0.001
Home	2177 (10.91)	17,772 (89.09)	
Hospital	1034 (7.40)	12,941 (92.60)	

terms of community-level showed significant small changes to estimated parameters. The p-value for frailty test under the Cox frailty model provided evidence that community-level shared frailty was significant at a 1% level of significance and the variance of frailty term was 0.20 (Table 2).

Table 2 highlights factors significant for mortality within age 5 years. In the model, maternal age, maternal education, paternal education, wealth status of the family, sex of the child, maternal age at first birth, number of living children, preceding birth interval, twin child, and child size at birth were significant factors for under-5 mortality. Mothers aged 20–29, 30–39, or ≥40 years had 70% [Hazard Ratio (HR) = 0.3; 95% Confidence Interval (CI): 0.2–0.4], 70% (HR = 0.3; 95% CI: 0.2–0.4) and 70% (HR = 0.3; 95% CI: 0.2–0.4) respectively lower risk of experiencing their children's demise before 5 years compared to children whose maternal age was <20 years. However, the oldest women's children had a lower risk of under-5 mortality than the youngest aged mother's children had.

Children of mothers who completed primary education were 0.9 (HR = 0.9; 95% CI: 0.8–1.0) times less likely to die before age 5 years compared to children of mothers with no education. However, fathers who completed primary education and higher education had 10% (HR = 0.9; 95% CI: 0.8–1.0) and 20% (HR = 0.8; 95% CI: 0.7–0.9) lower likelihood of under-5 mortality compared to fathers with no education.

The wealth index of families significantly impacted child mortality. The probability of dying was reduced by 30% (HR = 0.7; 95% CI: 0.6–0.8) for children from a rich family compared to children from a low-income family.

The likelihood of under-5 mortality was 1.2 (HR = 1.2; 95% CI: 1.1–1.2) times higher among male than female children.

First birth age of mothers at 18–30 years and >30 years had 10% (HR = 0.9; 95% CI: 0.8–1.0) and 30% (HR = 0.7; 95% CI: 0.4–1.0) lower risk of under-5 mortality compared to mothers with first birth at 12–17 years.

Children whose mothers had one or more living children were 0.1 (HR = 0.1; 95% CI: 0.0–0.1) times less likely to die before age 5 years than were children whose mothers had no live children.

Mothers with a preceding birth interval of 24–48 months and >48 months had a 20% (HR = 0.8; 95% CI: 0.7–0.9) and 20% (HR = 0.8; 95% CI: 0.7–0.9) lower risk of mortality compared to the children with birth interval <24 months. Children with birth interval >48 months were less likely to die before 5 years than children with birth interval <24 months.

The likelihood of child mortality was increased by 200% (HR = 3.0; 95% CI: 2.7–3.4) for children of twin/triple/other multiple births compared to single birth. The mortality risks were about 40% (HR = 1.4; 95% CI: 1.2–1.5) higher and 10% (HR = 0.9; 95% CI: 0.9–1.0) lower among children of small and large size at birth compared to children with average size.

Maternal working status, residence, and place of delivery had no significant association with under-5 child mortality.

4. DISCUSSION

Using recent NDHS 2018 data, this study obtained several proximate determinants or factors related to under-5 child mortality using Cox PH and Cox frailty models. Community frailty and regional frailty are two frailty terms added to the study. For the Nigerian children's dataset, the best-fitted model based on model selection criteria (i.e., AIC) was the community-level shared frailty

Table 2 Estimated hazard ratio for selected risk factors from Cox PH model and Cox frailty model of under-5 mortality

Characteristics	Cox PH		Cox frailty			
			Community frailty		Regional frailty	
	HR	95% CI	HR	95% CI	HR	95% CI
Maternal age (years)						
<20 (RC)						
20–29	0.32	[0.22–0.46]***	0.29	[0.20–0.42]***	0.29	[0.20–0.41]***
30–39	0.29	[0.20–0.42]***	0.26	[0.18–0.38]***	0.27	[0.19–0.38]***
≥40	0.28	[0.20–0.41]***	0.26	[0.18–0.38]***	0.25	[0.18–0.37]***
Maternal education						
Illiterate (RC)						
Completed primary	0.89	[0.80–1.00]*	0.94	[0.83–0.95]*	0.97	[0.87–1.09]
Secondary & higher	0.89	[0.79–1.01]	0.95	[0.84–1.07]	1.01	[0.89–1.15]
Paternal education						
Illiterate (RC)						
Completed primary	0.87	[0.78–0.98]**	0.86	[0.77–0.97]**	0.90	[0.81–1.01]
Secondary & higher	0.82	[0.73–0.91]***	0.80	[0.72–0.90]**	0.82	[0.74–0.91]**
Maternal working status						
Yes (RC)						
No	1.07	[0.99–1.15]	1.06	[0.98–1.14]	1.03	[0.96–1.12]
Wealth status of family						
Poor (RC)						
Middle	0.99	[0.90–1.09]	0.98	[0.88–1.08]	1.00	[0.91–1.10]
Rich	0.68	[0.60–0.77]***	0.67	[0.59–0.76]***	0.70	[0.62–0.79]***
Sex of child						
Female (RC)						
Male	1.16	[1.08–1.24]***	1.16	[1.08–1.24]**	1.15	[1.08–1.23]**
Maternal age at first birth (years)						
12–17 (RC)						
18–30	0.90	[0.84–0.97]**	0.91	[0.84–0.98]**	0.92	[0.86–1.00]*
>30	0.66	[0.44–0.99]*	0.66	[0.44–0.99]*	0.72	[0.48–1.08]
Number of living children						
0 (RC)						
≥1	0.07	[0. 05–0.08]***	0.06	[0.05–0.08]***	0.07	[0.06–0.08]***
Preceding birth interval (months)						
<24 (RC)						
24–48	0.79	[0.74–0.85]***	0.79	[0.73–0.85]***	0.79	[0.74–0.85]***
>48	0.77	[0.68–0.86]***	0.77	[0.68–0.87]***	0.79	[0.70–0.89]***
Birth status						
Single birth (RC)						
Multiple birth	2.99	[2.68–3.33]***	3.02	[2.69–3.39]***	2.88	[2.58–3.21]***
Child size at birth						
Average (RC)						
Small	1.32	[1.20–1.44]***	1.35	[1.23–1.49]***	1.31	[1.19–1.44]***
Large	0.96	[0.89–1.03]	0.94	[0.87–1.02]	0.94	[0.87–1.01]
Place of residence						
Urban (RC)						
Rural	1.06	[0.97–1.16]	1.09	[0.99–1.21]	1.07	[0.97–1.17]
Place of delivery						
Home (RC)						
Hospital	1.01	[0.92–1.10]	1.04	[0.95–1.15]	1.08	[0.98–1.19]
Variance of frailty term (SE)			0.20 (0.03)		0.03 (0.02)	
Likelihood ratio χ^2 of theta (p-value)			79.04***		31.21***	
AIC	41857.18		12911.63		12959.46	

*$p < 0.01$, **$p < 0.05$, ***$p < 0.001$. RC, reference category.

model. A previous study found similar dealing with the NHDS 2008 children's records [24]. Our results showed that before reaching their 5th birthday, children in Nigeria face community-level inequalities regarding mortality. For Nigerian under-5 mortality, the frailty model suggested strong evidence of high heterogeneity. The community-level frailty model, when compared with the regional-level frailty model, explained higher heterogeneity percentages. Thus, a preferable model for analyzing Nigerian under-5 mortality data is a community-level frailty model relative to the regional level frailty and traditional Cox PH model.

Children's health status and well-being are inter-related with their residing area since children are clustered under the same community. Therefore, the above-mentioned contextual influences may easily arise [25]. Additionally, community-level effects on individual child mortality create unobserved variation, which is difficult to understand. The impact of multiple unobserved risk factors can be abridged by the community variations that include paternal rearing, genetics, environment, health facilities, cultural norms, behavioral factors, siblings' resource competition, religion, etc. [25]. This study reported that maternal age and under-5 mortality are significantly inversely associated with increase in maternal age. The under-5 children's probability of dying reduces; this corresponds to previously conducted studies in Nigeria [26]. Young mothers may experience pregnancy difficulties, physical imperfection, financial crises, or malnutrition problems [27]. Additionally, inadequate health-related knowledge of those mothers during pregnancy and children upbringing could be another plausible reason [27].

We found a significant negative interaction between maternal education and child mortality. Maternal higher education plays a vital role in reducing under-5 mortality as it enhances awareness; similar findings were seen in earlier Nigerian studies that used different statistical tools [19,26,28]. Hence, mothers having an education can utilize health services, adequate care, and appropriate feeding practices to ensure better child health using their academic learning [26].

In unpredictable ways, the association between child mortality and paternal education is significantly inversely related. Studies conducted in Bangladesh and Uganda had similar findings, where children's good health was assured with reduced child mortality for educated fathers [14,29]. These study outcomes found that paternal and maternal education are crucial determinants of childrens' health. The findings suggest that paternal education is a protective factor for under-5 mortality in Nigeria. Additionally, healthy lifestyle goals and the bulk of health facilities may be of concern to educated fathers who promote good physical fitness. To explain this relationship more precisely, further investigation is necessary.

Families with low income have increased under-5 mortality risk compared to wealthy families, according to previous studies in Nigeria [26,28]. A household with low socioeconomic status fails to ensure facilities like well-furnished housing, sanitation, proper nutritional food, and expensive medical attention for children that can ultimately reduce child mortality risk [28]. Mothers from developing countries like Nigeria with low wealth status usually do not receive enough government grants to treat their children's illnesses and other health care. This could be a possible cause for increased child mortality among low-income households in developing countries [26].

There was a higher risk of under-5 mortality for male children compared to female children. This agrees with previous studies conducted in developing countries [13,26,28]. However, under-5 mortality is reduced in female children due to biological advantages, which helps fight different infectious diseases [25].

Under-five mortality is associated with maternal age at birth. Higher risk of under-5 mortality is reported among mothers who give birth at an early age, which agrees with previous studies [25,28,30]. Pregnancy complications cannot be handled properly due to the immature body structure of younger women [25].

Another significant factor reducing early childhood mortality is the current number of children of a mother. Hazards of under-5 mortality decrease for mothers having at least one living child, echoing a study conducted in Bangladesh [29]. Additionally, when women have surviving children, this improves their knowledge about upbringing and birth complexities, resulting in reduced child mortality.

We showed that preceding birth intervals play a crucial role in reducing child mortality. Our study suggested a lower risk of under-5 mortality when birth intervals were at least 2 years. Different countries (i.e., Nigeria, Bangladesh, and Ethiopia) that utilized DHS data found similar results [7,26,31–33]. Women who have short birth intervals have increased obstetric complications for their babies [31]. The study found an increased risk of under-5 mortality for multiple-birth babies compared with single-birth babies, which is consistent with a study conducted in Ghana [18]. However, multiple-birth babies often have complications during delivery, low birth weight, and nutrition intake competition. These can be potential causes of higher child mortality [27,34,35].

Low birth weight babies are more prone to die before reaching age 5 years than children of normal birth weight. Previous studies in Nigeria support this finding [7,29,31]. A low birth weight baby has several disadvantages such as immature organ development, malnutrition, and poor immunity to fight infectious diseases, causing an increased child mortality rate [29,36].

Most of our findings are similar to those of previous studies, although they were obtained through different statistical tools. However, some previous studies found several factors (i.e., place of residence, maternal working status, and place of delivery) to be significant determinants of child mortality, but our study did not find such results [25,26,31,33]. However, these dissimilarities in findings can be explained by the time gap between previous and current research, as our study used the most recent demographic data for Nigerian children.

There were several limitations to our study. (1) We used retrospective cross-sectional data, limiting the estimation of the causal effects. (2) The retrospective nature of the data could have resulted in reporting bias. The child mortality data were based on the mothers' memory, and it is natural to forget past events. (3) The exact causes of child death were not identified as the 2018 NDHS did not gather such information. (4) The cross-sectional setup of the survey was not optimal for obtaining maternal or household exact socioeconomic status at the time of child mortality. (5) Due to the incomplete data structure for maternal body mass index, breastfeeding history, antenatal care (ANC), etc., this essential information was not included in our study.

There were numerous strengths to the current study. (1) One advantage of using nationally representative cross-sectional data is the reflection of the true population as the sampling procedure uses a randomized technique with a large population. This study thus can draw a valid general conclusion about the population of Nigeria and similar countries. (2) The least sampling bias was ensured as the DHS program considers the whole population of a country before applying a two-stage stratified random sampling technique. (3) The DHS program provides transparency with its high response rate; this boosts precise estimates during statistical analysis. (4) The most valuable feature of the DHS program is that it does not encompass contextual factors information (norms, cultural practices, health facilities, customs, etc.). In such a situation, to decipher unobserved heterogeneity in child mortality, the frailty model is the most appropriate as the individual-level variables at the PSU level are not aggregated, ensuring a multicollinearity free environment [25]. Thus, surveys and censuses, which focus on community-level information, are essential for future research when the association is investigated between under-5 mortality and contextual factors.

5. CONCLUSION

This study identified maternal age, parental education, wealth index, child sex, maternal age at first birth, child size at birth, total number of living children, birth status, and preceding birth interval as being associated with under-5 mortality in Nigeria. Different health strategies might be required for children from double, triple, or multiple births. The government and NGOs should provide multiple births complexity-related knowledge to create awareness among women during the gestational period. Additionally, consideration of cluster effects can explain approximately 20% of the variation due to unobserved heterogeneity existing in under-5 mortality. Under-five mortality can be minimized by implementing maternal and child health-related programs. Furthermore, this study emphasized the necessity of incorporating community-level interventions for Nigerian communities that are economically, socially, and medically impoverished to reduce under-5 mortality.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

AUTHORS' CONTRIBUTION

AT and NJS contributed to study conceptualization and writing (review and editing) the manuscript. AT, NJS and MAI contributed to data curation, and formal analysis. AT, NJS, IH and SMSI wrote the original draft. AT supervised the project. All authors helped in writing (original draft) the manuscript, editing, and approval of the final form of the manuscript.

ETHICS COMMITTEE APPROVAL

This study was performed with the approval of the Institutional Review Board Findings Form ICF IRB FWA00000845 (approval number: 132989.0.000.NG.DHS.01).

REFERENCES

[1] Abir T, Agho KE, Page AN, Milton AH, Dibley MJ. Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004-2011. BMJ Open 2015;5;e006722.

[2] Deribew A, Tessema GA, Deribe K, Melaku YA, Lakew Y, Amare AT, et al. Trends, causes, and risk factors of mortality among children under 5 in Ethiopia, 1990–2013: findings from the Global Burden of Disease Study 2013. Popul Health Metr 2016;14;42.

[3] Al-Thani M, Al-Thani AA, Toumi A, Khalifa S, Ijaz MA, Akram H. Trends in the leading causes of childhood mortality from 2004 to 2016 in Qatar. Cent Asian J Glob Health 2018;7;334.

[4] Ogbo FA, Ezeh OK, Awosemo AO, Ifegwu IK, Tan L, Jessa E, et al. Determinants of trends in neonatal, post-neonatal, infant, child and under-five mortalities in Tanzania from 2004 to 2016. BMC Public Health 2019;19;1243.

[5] UNICEF, World Health Organization, World Bank, United Nations Levels & Trends in Child Mortality: Report 2017. New York: UNICEF; 2017. Available from: https://reliefweb.int/report/world/levels-and-trends-child-mortality-2017-report (accessed November 1, 2021).

[6] Akinyemi JO, Bamgboye EA, Ayeni O. New trends in under-five mortality determinants and their effects on child survival in Nigeria: a review of childhood mortality data from 1990-2008. Afr Popul Stud 2013;27;25–42.

[7] National Population Commission (NPC), ICF. Nigeria Demographic and Health Survey 2018 - Final Report. Abuja, Rockville, MD: NPC and ICF; 2019. Available from: http://dhsprogram.com/pubs/pdf/FR359/FR359.pdf (accessed November 1, 2021).

[8] UNICEF. Levels and trends in child mortality: report 2011. New York: UNICEF; 2011. Available from: https://reliefweb.int/report/world/levels-and-trends-child-mortality-2011-report.

[9] UNICEF. Levels and trends in child mortality: report 2014, Estimates developed by the UN Inter-agency Group for Child Mortality Estimation. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). New York: UNICEF; 2014. Available from: http://documents.worldbank.org/curated/en/953551468153557611/Levels-and-trends-in-child-mortality-report-2014.

[10] Dwomoh D, Amuasi S, Agyabeng K, Incoom G, Alhassan Y, Yawson AE. Understanding the determinants of infant and under-five mortality rates: a multivariate decomposition analysis of Demographic and Health Surveys in Ghana, 2003, 2008 and 2014. BMJ Glob Health 2019;4;e001658.

[11] Dendup T, Zhao Y, Dema D. Factors associated with under-five mortality in Bhutan: an analysis of the Bhutan National Health Survey 2012. BMC Public Health 2018;18;1375.

[12] Van Malderen C, Amouzou A, Barros AJD, Masquelier B, Van Oyen H, Speybroeck N. Socioeconomic factors contributing to under-five mortality in sub-Saharan Africa: a decomposition analysis. BMC Public Health 2019;19;760.

[13] Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. BMC Pediatr 2017;17;30.

[14] Nasejje JB, Mwambi HG, Achia TNO. Understanding the determinants of under-five child mortality in Uganda including the estimation of unobserved household and community effects using both frequentist and Bayesian survival analysis approaches. BMC Public Health 2015;15;1003.

[15] Kanmiki EW, Bawah AA, Agorinya I, Achana FS, Awoonor-Williams JK, Oduro AR, et al. Socio-economic and demographic determinants of under-five mortality in rural northern Ghana. BMC Int Health Hum Rights 2014;14;24.

[16] Mohammad KA, Fatima-Tuz-Zahura M, Bari W. Fine and Gray competing risk regression model to study the cause-specific under-five child mortality in Bangladesh. BMC Int Health Hum Rights 2017;17;3.

[17] Aheto JMK. Predictive model and determinants of under-five child mortality: evidence from the 2014 Ghana demographic and health survey. BMC Public Health 2019;19;64.

[18] Cox DR. Regression models and life-tables. J R Stat Soc 1972; 34;187–202.

[19] Mahmood S, Zainab B, Latif AHMM. Frailty modeling for clustered survival data: an application to birth interval in Bangladesh. J Appl Stat 2013;40;2670–80.

[20] Wienke A. Frailty models in survival analysis. Boca Raton, London, NY: CRC Press; 2010.

[21] Zike DT, Fenta HM, Workie DL, Swain PK. Determinants of under-five mortality in Ethiopia: an application of Cox proportional hazard and frailty models. Turkiye Klinikleri J Biostat 2018;10;123–36.

[22] Hanagal DD, Sharma R. Comparison of frailty models for acute leukemia data under gompertz baseline distribution. Commun Stat 2015;44;1338–50.

[23] Burnham KP, Anderson DR. Multimodel inference: understanding AIC and BIC in model selection. Sociol Methods Res 2004;33;261–304.

[24] Adedini SA, Odimegwu C, Imasiku EN, Ononokpono DN, Ibisomi L. Regional variations in infant and child mortality in Nigeria: a multilevel analysis. J Biosoc Sci 2015;47;165–87.

[25] Khan JR, Awan N. A comprehensive analysis on child mortality and its determinants in Bangladesh using frailty models. Arch Public Health 2017;75;58.

[26] Adekanmbi VT, Kandala NB, Stranges S, Uthman OA. Contextual socioeconomic factors associated with childhood mortality in Nigeria: a multilevel analysis. J Epidemiol Community Health 2015;69;1102–8.

[27] Kamal SMM. What is the association between maternal age and neonatal mortality? An analysis of the 2007 Bangladesh Demographic and Health Survey. Asia Pac J Public Health 2015;27;NP1106–NP17.

[28] Wegbom AI, Essi ID, Kiri VA. Survival analysis of under-five mortality and its associated determinants in Nigeria: evidence from a survey data. Int J Stat Appl 2019;9;59–66.

[29] Chowdhury AH. Determinants of under-five mortality in Bangladesh. Open J Stat 2013;3;213–19.

[30] Kayode GA, Adekanmbi VT, Uthman OA. Risk factors and a predictive model for under-five mortality in Nigeria: evidence from Nigeria demographic and health survey. BMC Pregnancy Childbirth 2012;12;10.

[31] Gebretsadik S, Gabreyohannes E. Determinants of under-five mortality in high mortality regions of Ethiopia: an analysis of the 2011 Ethiopia Demographic and Health Survey data. Int J Popul Res 2016;2016;1602761.

[32] Rhoda M, Beatrice NB, Panse DS, Sunday I, Stephen Y. Demographic and socioeconomic factors associated with under-five mortality in Nigeria's federal capital territory. J Soc Sci Human 2019;2;43–50.

[33] Aheto JMK, Keegan TJ, Taylor BM, Diggle PJ. Childhood malnutrition and its determinants among under-five children in Ghana. Paediatr Perinat Epidemiol 2015;29;552–61.

[34] Amoroso CL, Nisingizwe MP, Rouleau D, Thomson DR, Kagabo DM, Bucyana T, et al. Next wave of interventions to reduce under-five mortality in Rwanda: a cross-sectional analysis of demographic and health survey data. BMC Pediatr 2018;18;27.

[35] Anney AS, Rudra S, Biswas SC. Factors affecting under-five child mortality in Bangladesh: Cox proportional hazard model and cox frailty model. Int J Biomed Public Health 2020;3;15–24.

[36] Tabutin D, Masquelier B, Grieve M, Reeve P. Mortality inequalities and trends in low-and middle-income countries, 1990-2015. Population 2017;72;221–96.